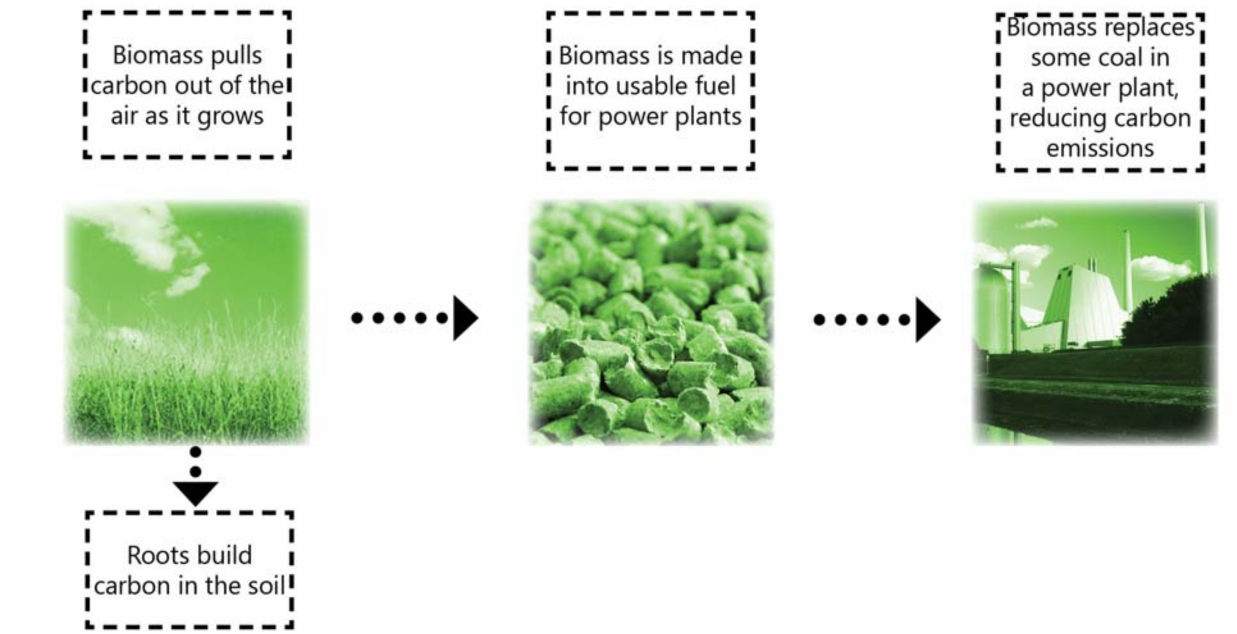
Feasibility Study of a Biomass Supply for the Spiritwood Industrial Park

NDIC Contract No R001-003



Final Report June 30, 2009

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SUBMITTED BY:
Great River Energy
Great Plains Institute
ND Association of Rural Electric Cooperatives
ND Dept of Agriculture
ND Farmers Union
ND Natural Resources Trust

Table of Contents

List of Tables

List of Figures

I. Executive Summary

The purpose of the Biomass Co-firing Feasibility Assessment is to ascertain whether a sustainable biomass business model can be developed in the area of Spiritwood, North Dakota. As a potential purchaser of biomass fuel, Great River Energy finds itself in a classic chicken and egg situation. There is no established biomass supply chain because the market does not exist and no market because the supply chain does not exist.

The primary driver for Great River Energy's interest in co-firing biomass is to reduce future emissions of carbon dioxide (CO_2). Co-firing biomass offers a one for one emission offset for every ton of coal displaced. As the cost of emitting CO_2 increases in the future, co-firing biomass could provide a real opportunity to maintain or reduce costs for energy consumers.

This study aims to evaluate the specific types of biomass that may readily exist or be established in the future, along with co-firing characteristics, and likely delivered costs. From a prospective producer standpoint, the study lays out a process schematic for the biomass harvest and delivery business model along with tools to help evaluate the economic costs and benefits of entering this market.

A diverse team of stakeholders has been assembled to work on this project and university researchers have been subcontracted for these specific tasks:

* Inventory of biomass within a 50 mile radius of Spiritwood, ND
* Matrix showing delivered costs and suitability for co-firing
* Densification options and costs
* Process schematic for biomass supply chain
* Prospects for recruiting existing farmland and CRP into dedicated energy crops
* Producer Economic Model for evaluating alternative cropping scenarios

Table 1 - Top 5 Biomass Sources for Spiritwood, North Dakota

Biomass	**TPY (% available)**	**BTU/lb**	**Delivered Cost $/dry ton**	**$/MMBtu**
Corn cobs	400,000 (17.5%)	6,900	50	3.60
Grasses CRP	*3,500,000 (2%)*	*7,500*	*50*	*3.80*
Corn stover	1,200,000 (5.8%)	6,600	50	3.60
Wheat straw	690,000 (10%)	7,000	50	3.35
Beet foliage	100,000 (70%)	7,000	42	3.00

With estimated delivered cost of biomass at $40 to $80 per ton ($3 to $4/MMBtu), biomass co-firing can be cost effective at CO_2 costs above $25/metric tonne. In addition to developing a biomass supply infrastructure for co-firing up to 10 percent biomass at Spiritwood Station, there is significant potential for supplying 100 percent biomass feedstock to cellulosic biofuels or industrial biochemical plants that may elect to locate in North Dakota.

II. Project Background

Great River Energy was awarded a North Dakota Industrial Commission Renewable Energy Council Grant to perform a detailed technical evaluation of the prospects for integrating a biomass supply to co-fire up to 10 percent biomass at Spiritwood Station in Jamestown, North Dakota. This project is being conducted through a unique partnership of industry, wildlife conservation groups, agricultural interests, and the financial community with significant matching contributions in cash and in-kind services. The team has been meeting for more than one year to prepare for and work on activities and tasks related to this program.

Quarterly team meetings and monthly conference calls have been conducted to date. A dedicated project website has been established for team members to easily share documents and coordinate meeting schedules.

Great River Energy and Great Plains Institute issued the following Requests for Proposals on behalf of this project and have subsequently awarded the following subcontracts:

1. Great Plains Institute – Program Management (NDIC Funds)
2. UND EERC – Tasks 1 through 3 (NDIC Funds)
3. NDSU – Tasks 4 and 5 (NDIC Funds)
4. NDSU – Task 6 – Producer Economic Model (GPI Funds)
5. Great Plains Institute - GHG Certification Scan (GRE Funds)

Table 2. Project Schedule Overview

2008				2009	
1Q	2Q	3Q	4Q	1Q	2Q
Secondary research					
		RFPs	Subcontracts awarded 10/31/2008		GRE economic model
EERC	GIS Data →		Biomass inventory		
				Densification options	
				Delivered costs	
NDSU				Process schematic	
			Land conversion prospects Producer Focus Groups March 2-3		
NDSU			Producer economic model		
				Producer meeting 3/20	
Team			Progress report 12/31/2008	Draft report 4/30/2009	Final report 6/30/2009

III. RESULTS & DELIVERABLES

A. Biomass Inventory

The University of North Dakota's Energy & Environmental Research Center (EERC) was selected to develop a Biomass Inventory within 50 mile radius of Project Site using published data on crop production, CRP land and surveys of nearby industrial and agricultural processing plants. EERC collaborated with ND Game & Fish and US Fish & Wildlife Service to secure data and respond to specific data requests (Land ownership category, current status (CRP, Wetlands, Prairie or Crop)). EERC did expand the delivery radius to 100 miles in order to quantify the volume of MSW and waste wood that may be available from nearby population centers.

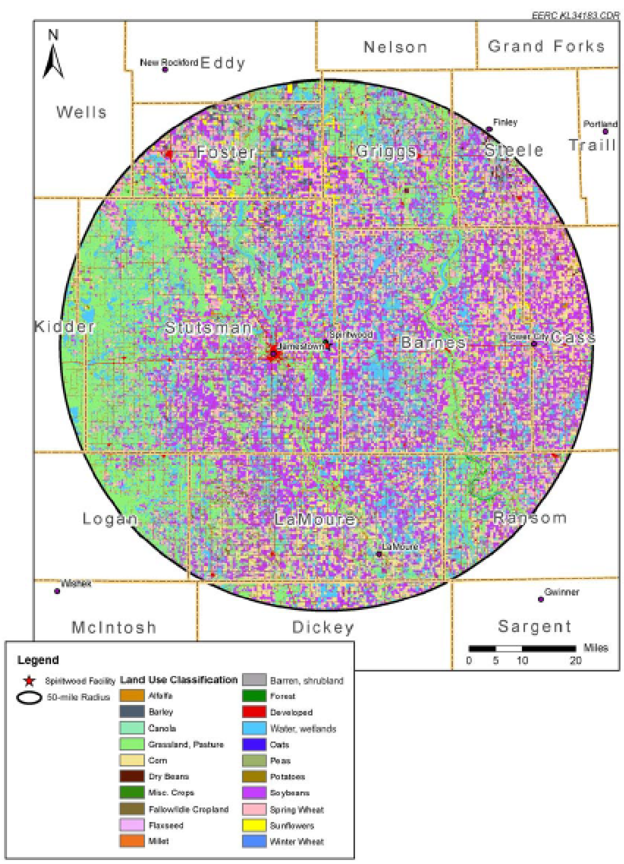


Figure 1. 2008 land use of GRE study region surrounding CHP Spiritwood facility.

Figure 1 (above) shows the color coded map showing 2008 land use within a 50 mile radius of Spiritwood.

Table 1 (below) gives a snapshot of the tons per year (TPY) of "waste" resources available within a 50 mile radius of Spiritwood facility.   Ten percent co-firing would require approximately 65,000 – 70,000 tons per year of dry biomass. The detailed study data is included Appendix C.

Table 3. Biomass Resources within 50 mile radius of Spiritwood, ND

Biomass Resource	Acres	Tons per Year
Corn	720,000	Cobs 400,000
		Stover 1,200,000
Wheat	640,000	Straw 690,000
Switchgrass on CRP (est)	*470,000*	*3,500,000*
Hay	400,000	550,000
Barley	110,000	Waste 54,000
Sunflowers	72,000	Hulls 8,800
Sugar Beet	4,100	Foliage 100,000
Wood waste		14,000
MSW		13,000

Secondly, EERC was contracted to identify and evaluate up to 5 sources of biomass (dedicated perennial energy crops, crop residues, industrial and agricultural by-products) that could be delivered to the project site. EERC documented annual supply availability and calculated our requirements as a percent of overall availability. The end result was the Fuel Suitability Matrix including: fuel handling characteristics, energy, moisture, ash and mineral content for each biomass type (See Table 5 below).

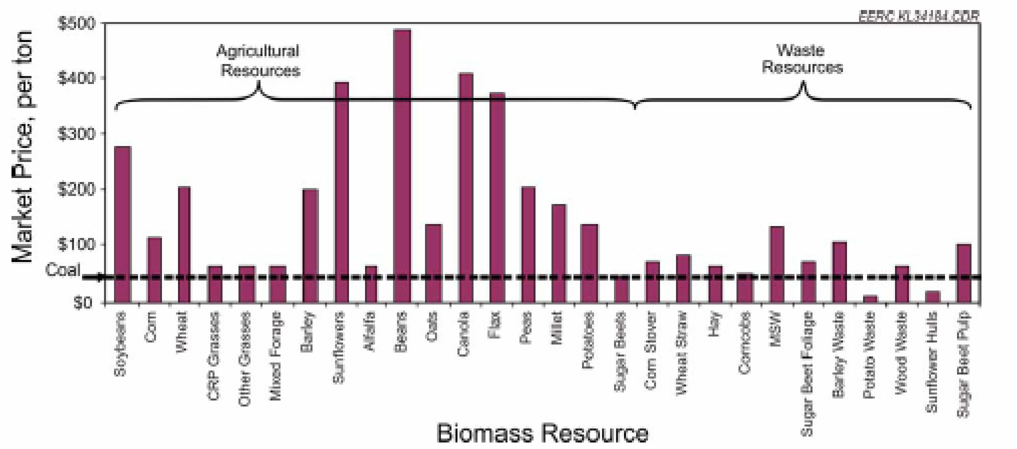


Figure 2. Value of biomass resources within the GRE study region.

Table 4. Costs and Comparison for Top 5 Biomass Resources

Biomass (per dry ton)	**Commodity** (nutrient value)	**Harvesting**	**Transportation** (up to 50 miles)	**Grinding**	**Total** Delivered
Corncobs	$0	$31	$14	$4	$49
Corn Stover	$16	$16	$14	$4	$50
Switchgrass	$8	$23	$14	$4	$49
Wheat Straw	$16	$16	$14	$4	$50
Sugar Beet Foliage	$8	$16	$14	$4	$42

B. *Densification Options*

In order to overcome certain bulk handling and fuel feeding issues in biomass storage and feed, some level of processing or densification is recommended. EERC performed a cost benefit analysis on densification strategies compared to bulk handling, analyzing the equipment and facilities required.

Table 5. Densification Cost Comparison

Processing 10 MW	**Grinding 5000 Btu/lb**	**Grinding + Pelleting 10,000 Btu/lb**	**Gasification 5000 Btu/ft^3**
Estimated Capital	$625,000	$900,000	$22,600,000
Annual O&M	$245,000	$1,925,000	$8,700,000
Levelized Cost	$300,000	$2,000,000	$10,000,000
Added Cost per ton	$4.25	$30	$150
Cost per mmBtu	$0.43	$1.50	

Another way of looking at the cost-benefit of various densification options is shown in the table below; it compares value-added forms of biomass. Cubes and pellets have an increased energy density, more comparable to a higher value coal such as PRB. Gasification is a higher value form yet, suitable for displacing natural gas.

Table 6. Densification Technology Cost-Benefit Analysis

Avg. per ton	Grinding	Cubes/Pellets	Gasification
Base Price	$40	$40	$40
[plus]	+	+	+
Density Cost	$4	$29	$74
[equals]	=	=	=
Feedstock Cost	$44	$69	$114
[minus]	–	–	–
Feedstock Value	$50	$55	$86
[equals]	=	=	=
Benefit	$6	($14)	($28)

*C. **Process Schematic***

North Dakota State University (NDSU) was selected to develop a Process Schematic for each type of biomass showing where each value added step is performed and by whom. They were asked to identify major new equipment requirements and capital cost at each step. Finally, we wanted to evaluate options and recommend one or more business models, showing which party might be responsible for the various steps and value added processing all along the way.

NDSU took a new business creation approach to defining all of the steps required to bring a biomass resource from the field to power plant fuel yard without regard to who might take responsibility for any given steps. By defining the entire process, we can more easily look at different business models with existing market participants or completely new intermediaries.

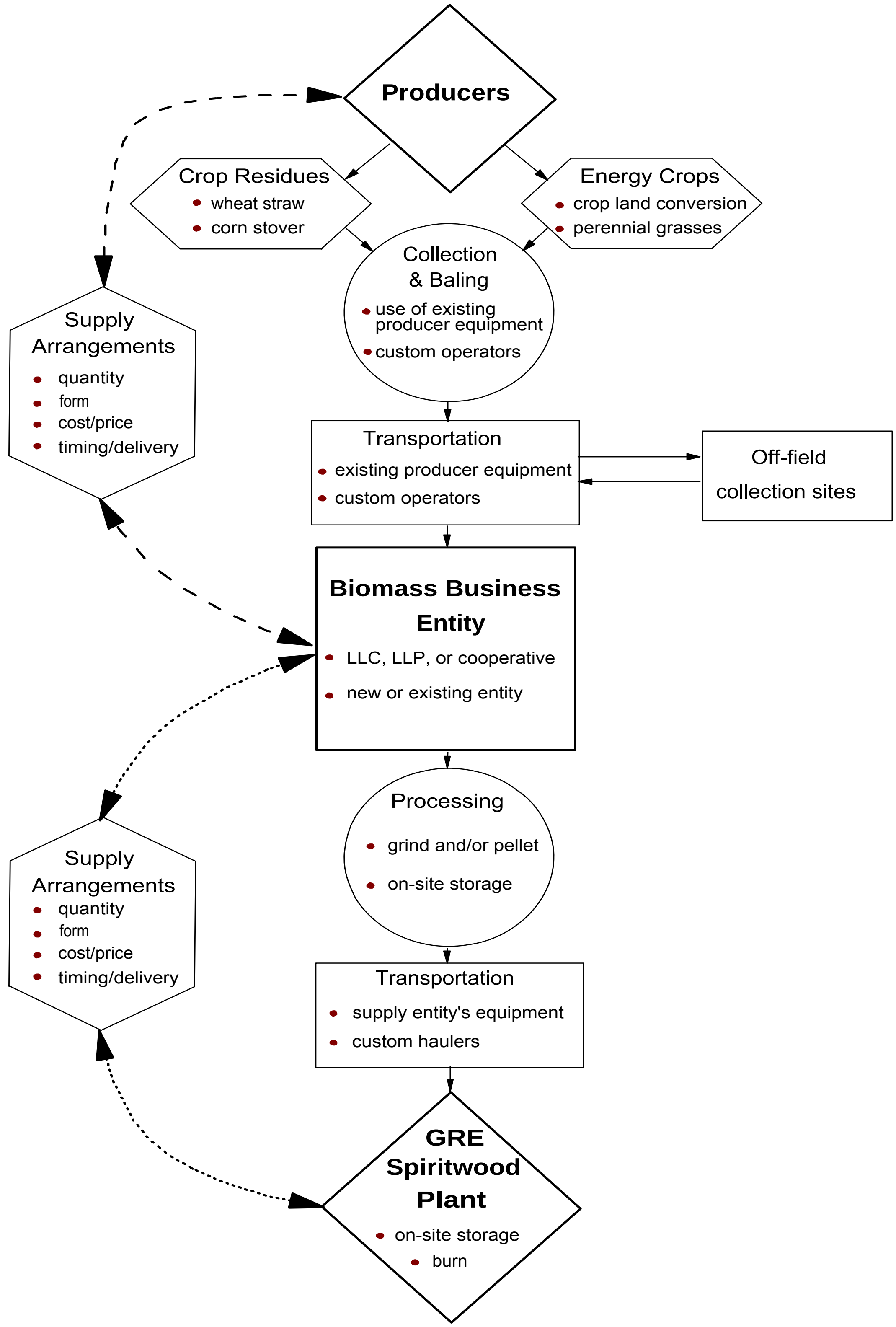
We looked at the “Show Me Energy” business model where an entirely new cooperative was formed to organize producers and process the biomass into a value added pellet fuel bagged for residential heating and sold in bulk for industrial and utility boiler fuel. The advantages of this business model include producer ownership and control of a new entity to fill the new roles and responsibilities created by this new market opportunity. By creating a new cooperative, the new equipment is financed by the entity itself, and fewer, larger contracts are negotiated with buyers and sellers. In addition, there is a natural incentive to leverage other business opportunities (new markets, new products) for the benefit of the cooperative.

It is likely that some intermediate or regional storage and processing facilities would be created around this opportunity. Biomass harvest will probably take place within a relatively short window in the fall. We anticipate the need to shelter the full year’s fuel requirement

In any case, plant modifications would be required at the power plant to handle and store some level of inventory in the fuel yard. It is likely an additional building would be needed to protect the biomass from the weather, and perhaps some of the value added processing could be done onsite.

Figure 3 below shows all of the steps required to produce, harvest, transport, process and deliver biomass fuel to the power plant.

Figure 3


Producers
Crop Residues
wheat straw
corn stover
Energy Crops
crop land conversion
perennial grasses
Collection & Baling
use of existing producer equipment
custom operators
Supply Arrangements
quantity
form
cost/price
timing/delivery
Transportation
existing producer equipment
custom operators
Off-field collection sites
Biomass Business Entity
LLC, LLP, or cooperative
new or existing entity
Processing
grind and/or pellet
on-site storage
Supply Arrangements
quantity
form
cost/price
timing/delivery
Transportation
supply entity's equipment
custom haulers
GRE Spiritwood Plant
on-site storage
burn

D. ***Prospects for recruiting existing farmland and CRP***

NDSU was selected to evaluate the prospects for recruiting existing farmland into perennial energy crops based on economics above and barriers. They were asked to catalog current incentives, requirements, funding and expiration. From this, we wanted to solicit producer feedback and concerns using small focus groups and develop one or more model fuel supply contracts with relevant term.

Feasibility Study Focus Group Summary

This summarizes findings from three focus groups conducted March 2-3 in Carrington, Jamestown, and Streeter. A total of 21 producers participated in these sessions. One observation from these groups was that most producers were not aware of the Spiritwood project and its commitment to use biomass. Thus, they had not had much opportunity to reflect on how supplying biomass would fit into their farming or ranching operation. The participants' responses to various issues are summarized below.

Entity to Coordinate Biomass Supply

As noted, most producers had not been aware of the Spiritwood project and so had not given the issue of a supply entity much thought. During the discussions, it became clear that there would be a number of tasks for the entity to perform. Some producers would be able to bale their own biomass, but others would need to have it custom baled. Most would likely want a third party to haul the biomass and would likely want bales removed from the field within one month. The supply entity could arrange baling, transportation and delivery of biomass.

Opinions varied on what form of entity would be appropriate. A cooperative was mentioned as a possibility, but producers were reluctant to invest in a new co-op, citing previous unsuccessful ventures. Others felt a private or corporate structure would be a better model. Another suggestion was that an existing hay broker might be able to add biomass supply to his business.

Contract Considerations

Producers expressed some concerns about contracts, citing problems with quality specifications on barley contracts and also that VeraSun had not honored its contracts for corn. An overriding comment was that contracts would need to cover all costs and provide the producer an incentive. Growers supplying agricultural residues were felt likely to prefer annual contracts so they could decide how much to supply on a year to year basis. These growers would also be comfortable contracting to supply a given quantity of biomass.

Different considerations would apply for producers who were supplying a dedicated energy crop. These growers would almost certainly need a multi-year contract covering the biomass produced from a given acreage. Growers also would want to see a mechanism to adjust contract payments if returns from competing crops were to change.

Interest in supplying different forms of biomass varied among groups. One group made up primarily of beef producers from an area with sandy soils had little interest in supplying agricultural residues, citing the value of returning residues to the soil. They would be more interested in a dedicated energy crop, but their main concern seemed to be livestock feed (and a concern that a biomass project would compete for available feed resources). (Of course, feed is a major issue this year, with a short hay crop and long winter.) Another group, dominated by farmers with more productive land, felt that crop residues would be readily available. Flax straw would be easy to buy as growers must bale or burn it to prepare for the next crop. Wheat and small grain straw and corn stover are other residues that should be readily available. Many growers would like to get their stover harvested as an aid in preparing for the next crop.

Other Considerations

As mentioned, the growers had not known much about the Spiritwood project prior to the meetings. After the Minnesota renewable mandates were explained, producers in two groups asked what would happen if the mandates went away. On the other hand, given a virtually guaranteed market based on mandates, some growers could see the opportunity for developing a supply entity. Risk should be less than for many new ventures.

E. ***Producer Economic Model***

"Biomass Compare 2009" was developed by Cole Gustafson, Ron Haugen, Dwight Aakre and Andrew Swenson under contract from the Great Plains Institute as a part of this feasibility study. This tool was demonstrated for prospective producers at the March 20, 2009 Producer Meeting in Jamestown to solicit feedback on functionality and possible enhancements.

Prices which provide the same Return over Variable Costs between crops — **Example from East Central N.D.**

Select reference crop	S. Wht
Enter the S. Wht futures price	$6.50
Enter expected local basis (cash-futures) usually negative	-$0.50
Expected S. Wht local cash price	$6.00

												----------Bio Mass----------	
	S. Wht	Barley	Corn	Soybean	Drybeans	Oil Snflr	Conf Snflr	Canola	Field Pea	W.Wht	Flax	Switchgrass	Corn Stover
Yield	39	58	101	31	1360	1420	1260	1000	34	44	18	4	4
Relative Price	$6.00	$3.69	$3.46	$6.89	$0.19	$0.16	$0.20	$0.26	$6.03	$5.59	$10.00	$50.93	$50.16
Income	$234.00	$213.82	$349.25	$213.50	$255.33	$234.30	$256.27	$258.02	$205.02	$246.07	$180.08	$203.73	$200.63
Variable costs:													
Seed	$14.10	$11.40	$62.65	$46.56	$42.00	$23.54	$37.05	$39.50	$33.00	$8.75	$9.80	$9.80	$9.80
Herbicide	17.00	14.00	17.00	17.00	33.30	22.00	22.00	18.00	20.40	17.00	17.00	8.00	17.00
Fungicide	5.50	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00
Insecticide	0.00	0.00	0.00	8.00	0.00	6.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00
Fertilizer	67.45	61.33	96.34	11.44	30.09	44.71	37.54	69.93	14.53	78.52	28.06	30.00	28.06
Crop Insurance	13.40	6.70	23.00	10.80	19.70	10.70	14.70	13.00	14.50	13.40	9.90	0.00	9.90
Fuel & Lube	11.78	13.48	17.51	10.67	13.86	13.12	12.88	11.96	12.56	10.61	11.73	17.00	11.73
Repairs	13.35	14.53	18.05	13.66	16.14	14.21	14.06	13.57	14.64	12.55	13.61	10.00	13.61
Drying	0.00	0.00	20.20	0.00	0.00	2.84	2.52	0.00	0.00	0.00	0.00	0.00	0.00
Hauling*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	20.00
Misc	1.50	1.50	1.50	6.00	9.75	7.25	13.00	1.50	6.25	6.00	1.50	8.50	1.50
Operating Int.	3.96	3.42	7.05	3.41	4.53	3.97	4.56	4.61	3.19	4.29	2.52	2.84	3.07
Establishment	na	na	na	na	na	na	na	na	na	na	na	11.63	0.00
Total Var.Costs	$148.04	$127.86	$263.30	$127.54	$169.37	$148.34	$170.31	$172.07	$119.07	$160.12	$94.12	$117.77	$114.67
Return Over Variable Costs	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96	$85.96

Note: - Only variable costs are considered in this comparison. You can include an amount under "misc." to account for any differences between crops in fixed costs, labor, management and risk.

Figure 4 Sample screen from Biomass Compare 2009.

The software allows prospective biomass producers to compare various crop scenarios compared to conventional choices (reference crops). The inputs (seed, fertilizer, yield, etc.) can be customized to reflect individual farm productivity. It also allows for establishment costs to be amortized when establishing a brand new dedicated energy crops, where harvest yields may take two to three years to fully mature. The output is net income and return over variable costs for various crop selections – thus providing an analytic decision making tool.

IV. GRE Evaluation – Costs & Benefits

Great River Energy has developed proprietary internal models to evaluate the economic impact of co-firing biomass at Spiritwood Station. The benefits of co-firing closed loop biomass are well understood and readily calculated emissions reductions and off-sets as compared to the base fuel. The incremental value of these emissions is not known at this time, but can be modeled within a probable range of $5 to $50 per metric tonne derived from model legislation and forecasts by industry sources.

Delivered biomass cost + (O&M) + (P&I) $\leq$ Delivered coal + emissions cost .

$$\Delta$$

The costs of retrofitting plant and modifying operational procedures for co-firing are also reasonably well defined and can be significant. Because this is an emerging market, costs are expected to come down over time and with additional experience.

The air emission permit for Spiritwood Station would need to be amended to allow for the co-combustion of biomass fuels or the operation of a biomass gasification facility. The North Dakota Department of Health would act on the permit application within 18 months from submittal of a completed application. Preparing the application would typically take several months from the time that one or more types of biomass were selected. The overall schedule for permitting would be somewhat dependent upon the types of biomass included, the magnitude of emissions adjustment and the level of public concern. Any significant increase in emissions would also trigger a New Source Review (NSR), revised air quality impacts and Best Available Control Technology (BACT) Analysis. If federal funds are sought in the future, an Environmental Impact Statement under NEPA would add six to twelve months to the process. We will also need to evaluate any impacts on the quality or volume of water and wastewater as result of biomass co-firing, which may trigger an amendment to our industrial pretreatment permit for wastewater discharge via the City of Jamestown.

In the U.S., most of the early experience is focused on opportunistic “waste products” where the commodity itself is “free” (FOB source) or perhaps a net revenue generator (tipping fee). Due to the inherent bulk handling expense and low energy density of biomass, biomass is quite expensive compared to coal.

This study predicted a probable range of delivered biomass costs for various local sources from the ground up and in several alternative forms. Because the biomass supply chain does not yet exist, this is the least well understood area.

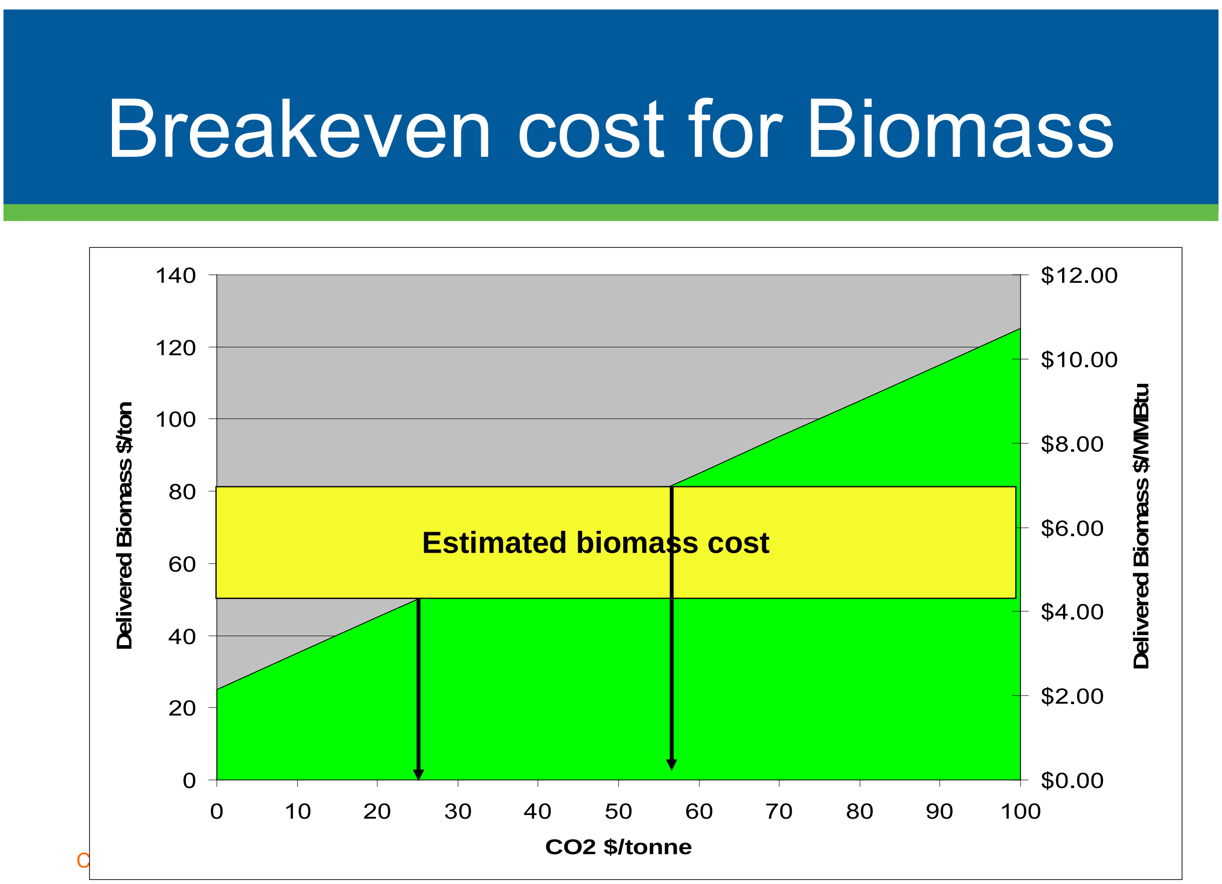
V. Summary and Conclusions

As a wholesale generation and transmission cooperative, Great River Energy’s mission is to deliver reliable, low cost electricity in an environmentally sustainable manner to serve its member cooperatives.

The cost of generating power is escalating and additional future costs for carbon dioxide emissions, whether “Carbon Tax” or “Cap and Trade” programs, will raise the cost of coal fired generation.   Great River Energy is evaluating various options to mitigate the impact on its members.

Co-firing of biomass with coal may present an opportunity to reduce CO_2 emissions and their associated costs without jeopardizing the reliability of the electrical system. Biomass is inherently more variable than coal, and requires some level of processing before it can be reliably stored, handled and co-fired. There will be some level of capital modifications required to existing power plant, depending on the final form of biomass fuel. The higher form value of biomass will likely require the least capital modification. The lower the form value of biomass, will likely require the highest capital modification, highest on-site fuel handling and storage and efficiency and outage penalties.
The following chart depicts the breakeven relationship in pricing between the delivered cost of biomass fuel and the future cost of CO_2 emissions. It shows that with the estimated delivered cost of biomass in the range of $40 to $80 per ton ($3 to $4.00 per MMBtu) shown in the yellow rectangle, biomass can be a cost effective replacement for refined North Dakota lignite whenever CO_2 costs exceed $25 per metric tonne.

Figure 5 Breakeven cost for Biomass



VI. APPENDICES

A. ***Appendix A***

GREAT RIVER ENERGY BIOMASS COFIRING FEASIBILITY ASSESSMENT

Final Report

(for the period of November 1, 2008, through June 30, 2009)

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EERC DISCLAIMER

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GREAT RIVER ENERGY BIOMASS COFIRING FEASIBILITY ASSESSMENT

EXECUTIVE SUMMARY

The Energy & Environmental Research Center assisted Great River Energy (GRE) in the determination of biomass energy options for a 99-MW combined heat and power (CHP) plant in Spiritwood, North Dakota. GRE is exploring the feasibility of cofiring up to 10% biomass in the lignite-fired circulating fluidized-bed power plant. The goal of this project was to identify the specific opportunities for GRE to procure and utilize biomass for energy production. A comprehensive study of biomass energy potential in the region was conducted to determine the current availability and delivered costs of biomass resources, as well as technical viability for utilization as a fuel, within 50 miles of the CHP facility. The evaluation of potential biomass densification options was also performed.

Corncobs and stover, grasses (i.e., U.S. Department of Agriculture Conservation Reserve Program grasses and switchgrass), sugar beet foliage, and wheat straw provide the most potential as feedstocks for the Spiritwood CHP facility, with about 3 million tons of biomass available annually at an average estimated price of $48/ton delivered and processed. About 60,000 tons/yr biomass would supply the 10% cofire rate. It is suggested to choose a feedstock low in alkalinity to avoid potential slagging or deposits in the furnace when cofiring biomass with coal. Expenses of delivered biomass incorporate harvesting, commodity, and transportation costs. Grinding the biomass feedstock prior to cofiring is also recommended to overcome bridging issues in storage and during combustion.

The following activities should be conducted prior to cofiring biomass at the CHP facility: sampling to determine the optimal harvesting time frame, a market study to determine the potential effect of the new demand, pilot-scale testing to address any potential operational issues, a full process design and complete economic analysis of biomass delivery and handling, the feed system and storage, and any modifications required to the CHP facility.

VII. INTRODUCTION

The Energy & Environmental Research Center (EERC) assisted Great River Energy (GRE) in the determination of biomass energy options for a 99-MW combined heat and power (CHP) plant in Spiritwood, North Dakota. GRE was awarded a grant from the North Dakota Industrial Commission to demonstrate the technical and economic feasibly of biomass utilization in a power plant in central North Dakota. GRE is therefore exploring the feasibility of cofiring up to 110 MMBtu/hour of biomass in a lignite-fired circulating fluidized-bed power plant. The CHP facility is currently under construction, providing GRE with the opportunity to make the design modifications necessary for cofiring up to 10% biomass.

The goal of this project was to identify the specific opportunities for GRE to procure and utilize biomass for energy production at the CHP Spiritwood facility. The EERC provided assistance to GRE by performing a comprehensive study of biomass energy potential in the region via the following objectives:

- Determine the current availability of biomass resources, as well as technical viability for utilization as a fuel, within 50 miles of the CHP facility
- Estimate delivered biomass costs to the Spiritwood, North Dakota.
- Evaluate biomass densification options, including gasification.

VIII. GRE CHP FACILITY

GRE is exploring the feasibility of cofiring biomass in a lignite-fired circulating fluidized-bed power plant. A range of 56,000 to 84,000 tons/yr biomass would supply a 10% cofire to the CHP facility, depending on feedstock energy density.

About 8.4 million MMBtu would be required annually for electricity and steam production from the GRE facility. The CHP facility will produce electricity and steam from about
610,000 tons/yr dried lignite. It is currently under construction, providing GRE with the opportunity to make the design modifications necessary for cofiring up to 10% biomass.

An average annual energy production of 650,000 MWh is estimated from the GRE facility. Based on data for North Dakota electrical generation facilities (Energy Information Administration, 2006), a conversion of 6500 hours per capacity MW was used to estimate annual energy production from the 99-MW CHP facility. With an efficiency of about 30% for coal to electricity, about 2.1 million MWh (7.2 million MMBtu) input energy source is required annually.

The CHP facility will also be supplying 200,000 lb/hr steam to the adjacent Cargill Malt plant. Since agricultural processing facilities average 260 days of operation annually, and using the rough conversion of 1000 Btu to generate 1 lb of steam, an additional 1.2 million MMBtu/yr input energy source is required annually.

An estimated 70,000 tons/yr biomass would be required on an energy basis, or 840,000 MMBtu/yr, to meet the 10% cofire feed rate. This feed rate could vary ±40%, depending on the energy density of the feedstock. For example, wood has an energy density similar to coal (~7500 Btu/lb), requiring 56,000 tons/yr to meet a 10% cofire rate, whereas about
84,000 tons/yr of a low-Btu feedstock (e.g., municipal solid waste [MSW] at 5000 Btu/lb) would be needed. Calculations are provided in Appendix A.

IX. REGIONAL BIOMASS INVENTORY

Corncobs and stover, grasses (i.e., U.S. Department of Agriculture Conservation Reserve Program [CRP] grasses and switchgrass), sugar beet foliage, and wheat straw provide the most potential as feedstocks for cofiring at the Spiritwood CHP facility. About 9 million tons of biomass could be available annually to supply the CHP facility. Prices for these biomass resources range from $10/ton to $500/ton. Choosing a feedstock low in alkalinity is recommended to avoid potential slagging or deposits in the furnace when cofiring biomass with coal.

A. ***Biomass Resources***

An estimated 9.3 million tons of agricultural and waste biomass is produced annually within an expanded study region surrounding the Spiritwood CHP facility. The majority of biomass is grain crops and agricultural processing or municipal wastes. Calculations for the biomass inventory are given in Appendix B.

Nearly all of the 5 million acres (83%) within a 50-mile radius of the CHP facility are farmland or undeveloped lands, as seen in Figure 1. The remaining land cover is developed, woodlands/forests, water/wetlands, and other miscellaneous types such as clover and wildflowers.

Crops from the farmland within the study region totaled 5.9 million tons (Farm Service Agency, 2008). Table 1 provides the acreage and yield of crops within the study region. The majority of the land is covered by grains (e.g., soybean, corn, and wheat) and grasses.

Other biomass resources include agricultural, industrial, and municipal waste, totaling 3.4 million tons annually (Table 2). These include corncobs and stover, wheat straw, hay, sugar beet foliage and pulp, sunflower hulls, potato and barley processing waste, MSW, and wood waste. Within the 50-mile radius surrounding the Spiritwood CHP facility, the sustainable harvest of MSW and wood is significantly low; therefore, the radius was expanded to 100 miles for these resources to include large population centers such as Fargo, North Dakota

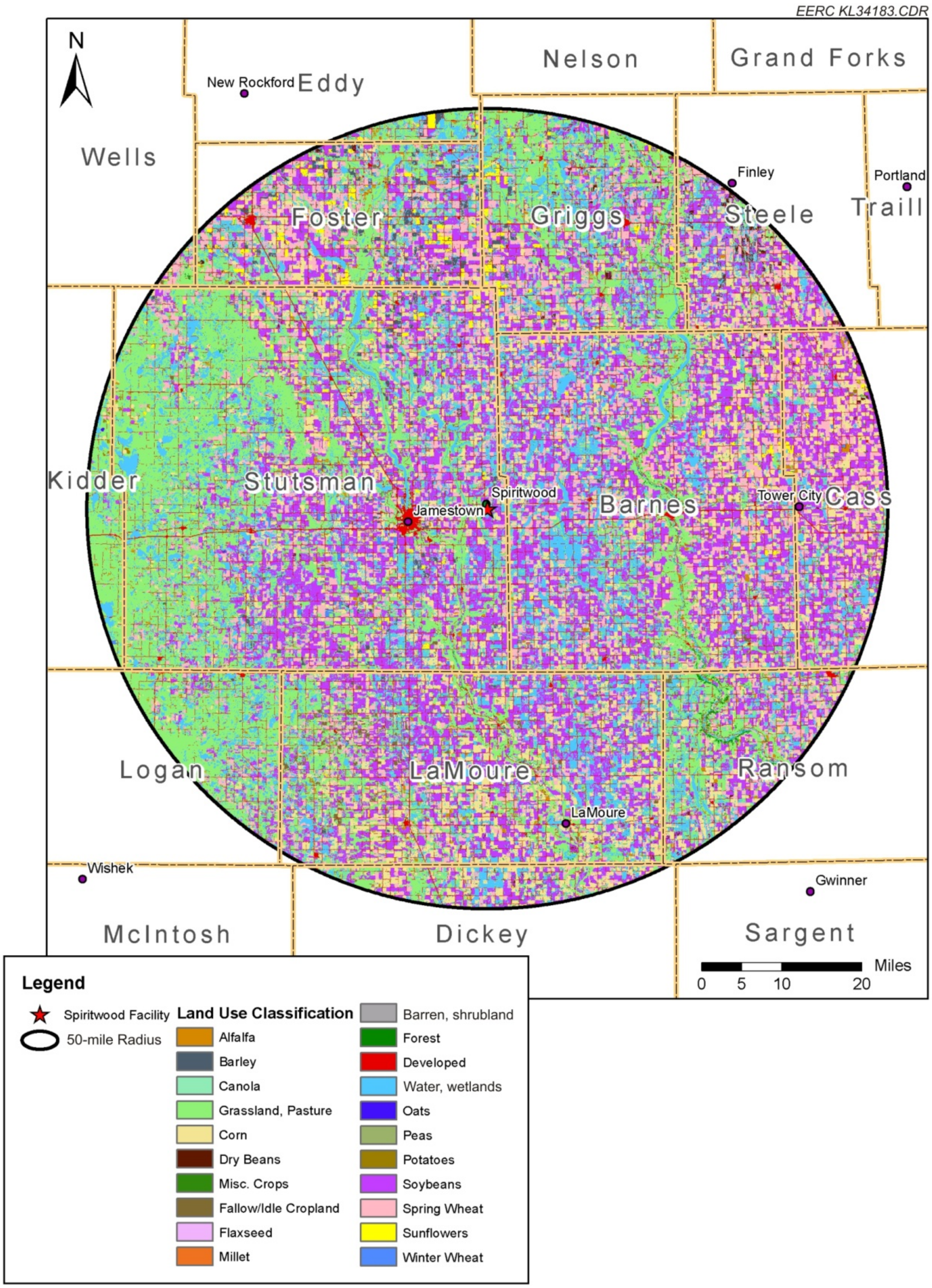

Figure 1. 2008 land use of GRE study region surrounding CHP Spiritwood facility.

Table 1. GRE Study Region Farmland Yield 2008

Land Cover	acres	tons
Soybeans	1,500,000	1,300,000
Corn[a]	720,000	1,600,000
Wheat	640,000	690,000
CRP[b]	470,000	700,000
Grass	300,000	720,000
Mixed Forage	120,000	290,000
Barley	110,000	140,000
Sunflowers[a]	72,000	50,000
Alfalfa	63,000	110,000
Beans	54,000	38,000
Oats	15,000	14,000
Canola	14,000	9,600
Flax	9,300	5,200
Peas	7,300	7,200
Millet	4,300	2,800
Potatoes	4,200	56,000
Sugar Beets	4,100	100,000
Fallow Farmland	110,000	–
Total	4,200,000	5,900,000

[a] Corn grain only; sunflower seeds without hulls.
[b] Assumes 3-yr management plan and access to lands expiring within 5 years.

Table 2. Waste Resources Within 50-mile Radius of Spiritwood, North Dakota

Waste Resource	tons/yr
Corn Stover	1,200,000
Wheat Straw	690,000
Hay	550,000
Corncobs	400,000
MSW*	330,000
Sugar Beet Foliage	100,000
Barley Waste	54,000
Potato Waste	44,000
Municipal Wood Waste*	14,000
Sunflower Hulls	8,800
Sugar Beet Pulp	5,500
Total	3,400,000

*Resources within 100-mile radius included.

Some of the waste generated within the GRE study region currently has established markets, such as hay, barley and potato waste, sunflower hulls, and sugar beet pulp. Hay is used for livestock feed and bedding throughout the region. At Cargill Malt, a majority of the waste is pelletized directly off of the malting process. A wet waste stream (20%–30% dry matter) is also generated. Barley waste products are currently sold for feed. A portion of the potato waste product is marketed as feed, but the remainder is currently disposed of. However, this product contains 70%–75% moisture. The ADM Northern Sun facility in Enderlin and Cargill's West Fargo facility processes about 80% of the sunflowers within the state of North Dakota. The majority of hulls generated from processing are burned at the facilities to reduce energy costs. Sunflower hulls are also used as roughage for ruminants and have also been marketed for specialty purposes such as poultry litter, fireplace logs, and other high-fiber products. Sugar beet pulp is currently pelletized and marketed as feed.

B. ***Biomass Value***

A preliminary economic analysis of the biomass resources showed great variance in price from $12/ton to $490/ton. Figure 2 compares the potential feedstocks with respect to dried lignite at an estimated price of $50/ton. The market prices of agricultural crops tend to be too high for use as an energy feedstock, whereas waste resources could be available at more economical prices.

Agricultural crops are priced in the range of $46/ton–$490/ton. Crop prices were derived from current market costs. Sugar beets and alfalfa have the potential to be more economically competitive for utilization at the CHP facility. Beans and peas are the most lucrative crops on a mass basis. Specific prices and references are provided in Appendix B.

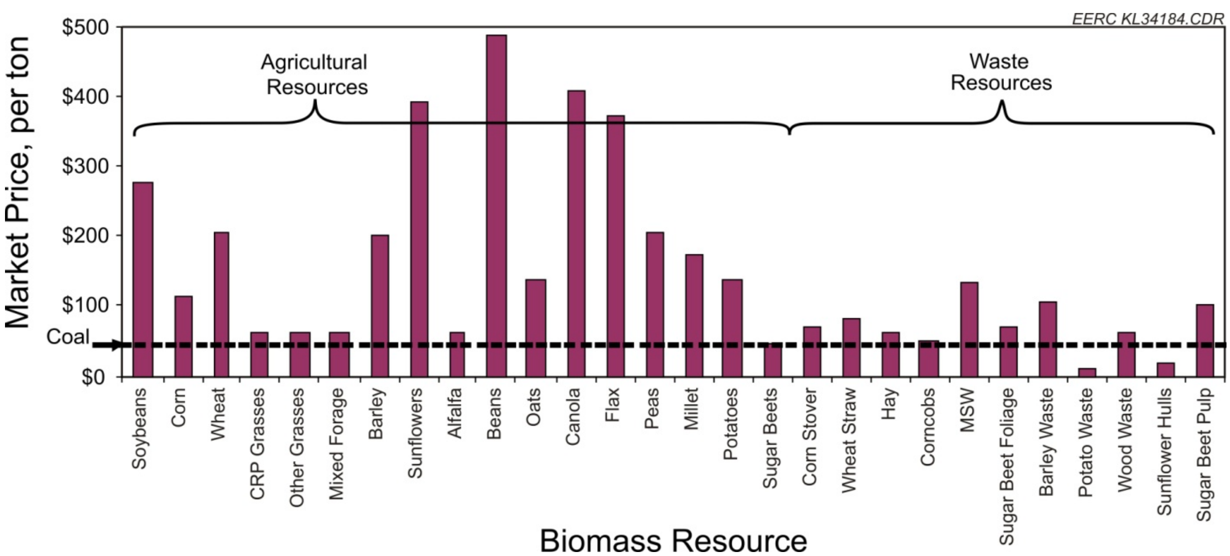

Figure 2. Value of biomass resources within the GRE study region.

Waste resources are available at about $12/ton–$130/ton. Potato waste and sunflower hulls could provide savings to the CHP facility as a feedstock significantly less than coal. Barley waste and MSW would be delivered at twice the cost of coal. References and calculations are also provided in Appendix B.

It should be noted that these prices are nationally published estimates for comparative purposes. A later section will examine the costs specific to North Dakota for procurement and delivery of the selected biomass types to the Spiritwood CHP facility.

C. “Top 5” Biomass Types

Based on value and availability (Table 3), corncobs and stover, grasses (i.e., CRP and switchgrass), sugar beet foliage, and wheat straw are considered the optimal potential feedstocks for cofiring at the Spiritwood CHP facility. An estimated 3 million tons of biomass is generated annually with preliminary market or delivered costs under $100/ton. An investment in new technology and/or infrastructure would be required as these resources are currently not harvested.

Preliminary pricing for agricultural residues and grasses range from $50/ton to $80/ton, totaling about 3 million tons of biomass annually. However, no equipment or infrastructure is currently developed for harvesting these resources within the GRE study region. Procuring may require investment in collection technologies and delivery method design. For example, relatively new harvesters, such as those from Vermeer Corporation, allow cobs to be separated from stover and collected during harvest.

Remaining biomass resources were determined to be insufficient, a high risk for market changes, or noneconomical. Actual availability of potato waste, sunflower hulls, or wood waste is < one-third the need for a 10% cofire at the Spiritwood CHP facility. Although the price of sugar beets is attractive, this price would likely increase with an increase in demand. Likewise, market prices would likely increase for hay and alfalfa with an increase in demand, as these products currently have sustainable markets. Biomass resources with estimated or market prices above $100/ton were considered too expensive for consideration at the CHP facility.

D. Biomass Cofiring

Formation of agglomerates is of potential concern when biomass is cofired with coal. Choosing a feedstock with ash content low in alkalinity and implementation of a sampling and harvesting plan can easily address this issue.

High alkali concentrations (potassium and sodium content) in fuel ash can cause slagging or deposits in the furnace. Potassium specifically interacts with silica and alumina material in coal ash to lower the ash melting temperature, causing agglomeration issues. Typical characteristics for the chosen biomass types are given in Table 4. Wide variability of alkalinity is apparent in biomass samples, ranging from 3 to 30 wt% of the ash as an oxide. Corrosion is not expected to be an issue because of low sulfur and chlorine content in biomass, often providing improvements when cofiring compared to coal alone.

Table 3. Evaluation of Identified Biomass Resources

Resource	Price/ton	Tons/yr	Comments
Coal Comparison	*$50*	*70,000*	--
Potato Waste	$12	44,000	70-75% moisture; 22% biomass need (dry)
Sunflower Hulls	$20	8,800	15% biomass need; Cargill & Northern Sun (ADM) utilize onsite for energy
Sugarbeets	$46	100,000	Established market; utilization will increase demand, increasing cost
Corncobs	**$50**	**400,000**	**No collection/delivery infrastructure**
CRP Grasses	**$60**	**740,000**	**No collection/delivery infrastructure**
Other Grasses	$60	720,000	Unknown lands/accessibility
Mixed Forage	$60	290,000	Unknown lands/accessibility
Hay	$60	550,000	Established market; utilization will increase demand, increasing cost
Switchgrass	**$60**	**TBD***	**Not currently available**
Alfalfa	$61	110,000	Established market; utilization will increase demand, increasing cost
Wood Waste	$63	14,000	30% biomass need
Corn Stover	**$69**	**1,200,000**	**No collection/delivery infrastructure**
Sugar Beet Foliage	**$69**	**100,000**	**No collection/delivery infrastructure**
Wheat Straw	**$80**	**690,000**	**No collection/delivery infrastructure**
Sugar Beet Pulp	$100	5,500	Too expensive for consideration
Barley Waste	$110	54,000	
Corn	$110	1,600,000	
MSW	$130	330,000	
Potatoes	$140	56,000	
Oats	$140	14,000	
Millet	$170	2,800	
Barley	$200	140,000	
Peas	$210	7,200	
Wheat	$210	690,000	
Soybeans	$280	1,300,000	
Flax	$370	5,600	
Sunflowers	$390	50,000	
Canola	$410	9,600	
Beans	$490	38,000	

* To be determined by future GRE efforts.

Table 4. Comparison of Top 5 Biomass Properties[1]

Fuel	Corncobs	Grasses	Switch-grass	Corn Stover	Wheat Straw	Dried Lignite
Proximate, % dry						
Moisture	15	4.7	6.2	10	8.8	26
Volatile Matter	80	75	77	76	79	41
Fixed Carbon	19	15	17	15	14	46
Ash	1.4	11	5.4	8.5	7.3	13
Ultimate, % dry						
H	5.9	5.7	6.0	6.2	5.9	6.5
C	47	41	43	44	41	38
N	0.5	1.1	0.9	0.4	0.8	0.6
S	0.0	0.2	0.1	0.0	0.2	0.8
O	46	41	45	42	46	42
Ash	1.4	11	5.4	8.5	7.3	13
Heating Value (Btu/lb)						
Gross	8100	7500	7900	7400	7600	9100
Net	6900	7100	7500	6600	7000	6800
Ash XRF (wt% as oxide)						
SiO_2	40	46	69	48	69	32
Al_2O_3	--	1.0	0.4	3.3	0.2	9.0
Fe_2O_3	4.1	0.9	0.4	2.0	0.6	11
TiO_2	--	0.1	0.1	0.3	0.1	0.4
P_2O_5	6.9	4.0	4.8	3.6	2.4	0.1
CaO	1.3	4.0	9.3	12	5.7	14
MgO	2.5	6.0	4.0	11	2.7	5.0
Na_2O	1.2	1.8	0.2	0.5	1.1	6.5
K_2O	2.0	27	9.8	15	14	0.9
SO_3	8.7	0.7	1.6	1.7	3.0	19
Cl	--	9.4	0.6	1.9	1.2	--
Alkalinity	3.2	28	10	16	15	7.4
Corrosion/ Emissions	8.7	10	2.2	3.6	4.2	19

[1] Average values for resources given; data for sugar beet foliage not available; average of grasses and residues used when necessary.
[2] X-ray fluorescence.

The high variability in composition with harvest source and season suggests a representative biomass sample be analyzed before committing to the resource as a cofire feedstock. During this assessment, one alfalfa sample was found to be an optimal cofiring feedstock in terms of little agglomeration potential, and a second alfalfa sample was found to be unacceptable for cofiring. Similarly, switchgrass was at one time considered unusable as an energy crop because samples taken in late summer had extremely high ash and alkali contents (Zygarlicke et al., 2001). Today, switchgrass is well-known as a potential energy crop. Lower alkali levels are observed early in the season before alkali is absorbed or very late as it is deposited back into the soil in preparation for winter dormancy.

X. BIOMASS DELIVERED COSTS

Biomass prices are estimated to be \$38/ton–\$46/ton delivered. Table 5 shows the sum of harvesting, commodity, and transportation expenses for each biomass type. Collection of corn stover and wheat straw may be a greater expense by weight, with the sugar beet foliage having the lowest cost.

Harvesting and bailing expenses are estimated to be \$16/ton–\$31/ton depending on biomass type. Current calculations for collection of corncobs suggest a cost of \$31/ton for procurement (Christiansen, 2009). CRP grasses and switchgrass would require cutting or mowing to harvest the material, followed by bailing. Adjusting previously published estimates in North Dakota (Aakre and Sedivec, 2002; Leistritz et al., 2007) for average diesel costs over the past 12 months (Energy Information Administration, 2009b), costs would be about \$23/ton to collect grasses. Based on custom bailing rates and similarly corrected for the recent diesel pricing, expenses for collection of corn stover, sugar beed foliage, and wheat straw are estimated to be \$16/ton.

Compensation to the farmer is expected to be \$8/ton–\$16/ton biomass supplied for the Spiritwood CHP facility. This value is related to the benefit of leaving agricultural residue on the field to return nutrients to the soil and prevent erosion. For example, corn stover and wheat straw are essential for returning nitrogen to the soil. Additional fertilizer must be applied to those areas where residues were removed to compensate for the lost nitrogen. Based on nutrient value (Leistritz et al., 2007) and adjusted for 2008 ammonia prices (Energy Information Administration, 2009a), this cost is estimated to be \$16/ton biomass procured. Grasses and sugar beet foliage offer little value for soil nutrients but provide some erosion control. Assuming a reduction in CRP payments from harvesting CRP grasses on a 3-yr management plant, a value of \$8/ton is estimated based on an average of North Dakota 2008 payments (Bevill, 2008). It was assumed the value of sugar beet foliage would be similar. Corncobs are recalcitrant to decomposition and do not contribute significantly to soil quality.

Transportation was estimated to be about $14/ton biomass. The conservative calculation was based on the average diesel cost over the past 12 months at $3.50/gallon (Energy Information Administration, 2009b) for a maximum distance of 50 miles between the resource supplier and the Spiritwood CHP facility.

XI. FEEDSTOCK DENSIFICATION OPTIONS

Grinding the biomass feedstock prior to cofiring is the only recommended densification technology for the Spiritwood CHP facility. Densification can be implemented to overcome bridging issues in storage and during combustion. Costs for densification range from $4/ton to $70/ton and provide a product value of $50 to $90/ton. Grinding provides a significant benefit to the operations of cofiring biomass, whereas cubing/pelletizing and gasification of the chosen feedstocks do not support implementation at the facility.

Table 5. Revised Costs and Comparison for Top 5

(per ton)	Harvesting	Commodity	Transportation	Total
Corncobs	$31	–	$14	$45
Grasses*	$23	$8	$14	$45
Corn Stover	$16	$16	$14	$46
Sugar Beet Foliage	$16	$8	$14	$38
Wheat Straw	$16	$16	$14	$46

* CRP grasses, switchgrass.

Light feedstocks such as grasses can cause bridging in storage and during combustion, increasing operating and maintenance costs (O&M); however, these issues can be overcome through densification and proper system design. Bridging impedes the flow of the feedstock either from storage or during combustion. The bridged material must be broken up physically, requiring the system to be shut down and operators to go into the storage bins or combustion system to restore flow of the feedstock material. In addition to bridging issues, long strands in the feedstock are difficult for auger conveyance, and if overly fine, the feedstock is too lightweight for pneumatic conveyance. Experience has shown that many issues with cofiring biomass and low-rank coal are addressed through proper system design and operation. It is thus recommended that grinding or other densification of the feedstock be conducted, regardless of which biomass type is used.

The value of a ground feedstock to the Spiritwood CHP facility is estimated to be equal to coal at $50/ton, and the total average cost of grinding is $4/ton biomass. Grinding the material to a uniform size eliminates the potential for bridging, maintaining O&M costs at the same level as the coal feedstock. The value of a uniformly sized feedstock is estimated to be equal to coal, assuming a price of $50/ton for dried lignite. If portability is not necessary, electrical stationary grinders are the most economical (Leroux, 2008). Capital investment for equipment is in the range of $250,000–$400,000 to process 12–24 tons/hr. Operating costs are about $2/ton–$5/ton for electricity at 40 kWh/ton. The estimated cost incorporates operating expenses and the amortized capital of the described equipment.

The value of a cubed or pelletized feedstock to the Spiritwood CHP facility is estimated to be about $55/ton, and the total average cost of cubing/pelletizing is $29/ton biomass. Cubes and pellets provide a product of uniform quality and low moisture (5%–10%) for more consistent flow and more efficient combustion. The value of this feedstock, therefore, is estimated to be $50/ton–$60/ton, equal to or more than coal. The estimated cost includes operation expenses and amortized capital of cubing/pelletizing equipment to process 60,000 tons annually. Cubing and pelletizing generates a dense product of 20–50 lb/ft^3 (½–1½" dia.) and 35–60 lb/ft^3 (⅛–¼" dia.), respectively. Capital investment for equipment is in the range of $800,000–$1,000,000, and operating costs are about $15/ton – $40/ton for electricity at 300–800 kWh/ton. These estimates do not include the grinding of the feedstock prior to processing. It is also important to note that cubes and pellets are a high-value product, up to $200/ton, in biomass markets without the competition of low-priced coal.

The equivalent value of biomass is about $86/ton for syngas production, and the total estimated cost of gasification at the Spiritwood CHP facility is $74/ton biomass. Gasification of biomass produces a low-Btu gas that can be used in many applications to replace natural gas for potential savings or to provide energy price stability. The biomass value assumes the produced syngas is used as a natural gas substitute, with industrial natural gas averaging $8.30/MMBtu for North Dakota in 2008 (Energy Information Administration, 2009a). Approximately 620,000 MMBtu syngas could be produced annually from 60,000 tons/yr biomass. The cost estimate includes operation expenses and the amortized capital of a 170-ton-biomass-per-day gasification system. Capital investment for the gasification system is an estimated $23 million, and operating costs are about $4.4 million annually. Operating expenses include labor and maintenance; a negligible amount of energy is consumed for equipment operation.

A cost–benefit analysis was conducted to evaluate the discussed densification technologies for suitability at the CHP facility, shown in Table 6, where a positive value indicates the technology is an asset (grinding) and a negative value implies a lack of benefit (cubes/pellets and gasification) to facility operations. A base price of $40/ton was used for the cost of the biomass feedstock prior to densification. The total average cost for each densification technology was added to the base price to achieve a representative cost of the densified product, i.e., ground material, cubes/pellets, syngas. The feedstock cost was then compared to the estimated value of the feedstock previously determined. The result is a positive or negative benefit value for the CHP facility.

XII. CONCLUSION

Biomass feedstocks chosen for cofire at the Spiritwood CHP facility are estimated to average $48/ton processed and delivered, with about 60,000 tons/year biomass required to meet the 10% cofire rate at the CHP facility. An average 20% of a chosen biomass availability would be consumed considering annual variability in crops planted and harvested.

The recommended biomass types are CRP grasses or switchgrass, sugar beet foliage, corn stover, wheat straw and corncobs, available at an estimated $42–$50/ton ($3.00–$3.80/MMBtu) and 55,000–65,000 tons/yr needed to meet the 10% cofire rate. Table 7 shows corn stover to provide the greatest resource and sugar beet foliage to be the most economical. Grinding expenses are included. Moisture and energy density values range from 5% to 15% and 6500 to 7500 Btu/lb, respectively. Total availability of resources range from 0.1 to 1.2 million tons/yr. Alkalinity may be a concern for all biomass types, with the exception of corncobs; however, values are highly variable depending on the time of the harvest.

Variability in the chosen biomass resources ranged from 8% to 34% over the last 5 years, with grasses, wheat straw, and corn stover having the most room for flexibility (Table 8). Estimated yield for corn residues are the most volatile, while grasses remain relatively constant. Biomass availability for wheat straw and sugar beet foliage changes moderately, up to 12% variance annually. When one considers the impact of variability on availability for utilization by the Spiritwood facility, usage of corn stover, grasses, and wheat straw is not expected to exceed 10% of the estimated availability within the study region. Consumption of sugar beet foliage and

Table 6. Densification Technology Cost-Benefit Analysis for the Spiritwood CHP Facility

Avg. per ton	Grinding	Cubes/Pellets	Gasification
Base Price	$40	$40	$40
[plus]	+	+	+
Density Cost	$4	$29	$74
[equals]	=	=	=
Feedstock Cost	$44	$69	$114
[minus]	–	–	–
Feedstock Value	$50	$55	$86
[equals]	=	=	=
Benefit	$6	($14)	($28)

Table 7. Top 5 Biomass Resources Recommended for Cofire at Spiritwood Facility

Rank	Biomass	Price/	Moisture	Btu/lb	tons/	Price/	Resource[e]	Alkalinity

		ton[c]			yr[d]	MMBtu		
1	Grasses[a]	$49	5%	7300	57,000	$3.40	740,000	19
2	Sugar Beet Foliage[b]	$42	7%	7000	60,000	$3.00	100,000	17
3	Corn Stover	$50	10%	6600	64,000	$3.80	1,200,000	16
4	Wheat Straw	$50	9%	7000	60,000	$3.60	690,000	15
5	Corncobs	$49	15%	6900	61,000	$3.60	400,000	3
	Coal Comparison	$50	26%	6800	62,000	$3.70	–	7

[a] CRP grasses, switchgrass.
[b] Characterization data averaged from values above.
[c] Includes grinding costs.
[d] Estimation required to meet 10% cofire rate.
[e] Estimated annual tonnage available.

Table 8. Sensitivity of Estimated Yield over 5-year History

Biomass	Average tons	Variance	Worst Case Min. tons	Worst Case Max. Use
Grasses*	860,000	8%	740,000	8%
Sugar Beet Foliage	130,000	12%	100,000	57%
Corn Stover	860,000	34%	540,000	12%
Wheat Straw	740,000	12%	660,000	9%
Corncobs	290,000	34%	180,000	34%

* CRP grasses, switchgrass.

corncobs could be as much as 60% and 35% of the available resource, respectively. Contracting a majority of the available crop residues could prove problematic logistically and may affect existing markets, increasing commodity pricing.

XIII. RECOMMENDATIONS

The following suggestions are recommended prior to implementation of biomass cofire within the Spiritwood CHP facility:

- Sampling of the chosen biomass should be conducted from the farms considered during various times throughout the growing season to determine the optimal harvesting time frame for minimal moisture and alkalinity content.

- A market study should be performed to ensure the chosen biomass is not currently sold and to determine how an increased or new demand may affect the commodity price of the biomass.

- Pilot-scale testing of the chosen biomass should be performed at the specified 10% cofire rate to address any potential operational issues.

- A full process design and engineering schematic should be generated of the biomass procurement, feed system, and any modifications required to the CHP facility.

- A complete economic analysis should be performed of biomass delivery and handling, feed system and storage, and any modifications required to the CHP facility.

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APPENDIX A

CALCULATIONS OF BIOMASS REQUIREMENTS

Table A-1. GRE Spiritwood Facility Energy Calculations

Facility Demand	Peak	Baseload
Power Output, MW	99	76.5
Power Output, MMBtu/hr	338	261
Energy Input, MMBtu/hr	1092	844
Estimation of Annual Energy Generation		
Electrical Energy		
All North Dakota Electric Utilities 2006*:		
Power Output, MW	4636	
Energy Output, MWh/yr	30,328,375	
Hours vs. Capacity (MW) Factor	6542	
Estimated Electricity Production:		
Energy Output, MWh/yr	647,651	
Energy Input, MWh/yr	2,093,724	
Energy Input, MMBtu/yr	*7,143,785*	
Steam Energy		
Supply to Cargill Malt, lb/hr	200,000	
Operation (avg.), days/yr	260	
Operation (avg.), hr/yr	6240	
Energy Input, MMBtu/hr	200	
Energy Input, MMBtu/yr	*1,248,000*	
Total Energy Input (Electric and Steam), MMBtu/yr	8,391,785	

* www.eia.doe.gov/cneaf/electricity/st_profiles/north_dakota.pdf (accessed December 2008)

Table A-2. Calculations for 10% Biomass Cofire at Spiritwood Facility

Cofire Demand	Peak	Baseload
Fuel Input, MMBtu/hr	109	84
Feed Rate, tons/hr		
7500 Btu/lb Biomass	7.3	5.6
5000 Btu/lb Biomass	11	8
Estimation of Annual Biomass Requirement		
Fuel Input, MMBtu/yr	839,178	
Feed Rate (avg.), tons/yr	69,932	
7500 Btu/lb Biomass	55,945	
5000 Btu/lb Biomass	83,918	

APPENDIX B

CALCULATIONS OF BIOMASS RESOURCES

Table B-1. Land Cover for Spiritwood Study Region

								Market Price		
Crop	**Acres[1]**	**Yield**	**Unit**	**Ref.**	**Conv.**	**Ref.**	**Tons/yr**	**Per unit**	**Ref.**	**Per ton**
Soybeans	1,459,784	30	bu/acre	2	60	5	1,313,805	$8.33	3	$278
Corn[a]	721,996	80	bu/acre	3	56	5	1,617,271	$3.20	3	$114
Wheat	641,543	36	bu/acre	3	60	5	686,451	$6.19	3	$206
Barley	108,399	55	bu/acre	3	48	5	143,087	$4.81	3	$200
Sunflowers[a]	71,561	1,410	lb/acre	3	1	–	50,451	$0.20	3	$392
Alfalfa	63,310	1.76	tons/acre	4	2000	–	111,425	$61.00	6	$61
Beans	53,662	1400	lb/acre	3	1	–	37,563	$0.24	3	$486
Oats	14,983	58	bu/acre	3	32	5	13,904	$2.24	3	$140
Canola	13,878	1380	lb/acre	3	1	–	9,576	$0.20	3	$406
Flax	9,299	20	bu/acre	3	56	5	5,208	$10.35	3	$370
Peas	7,319	33	bu/acre	3	60	5	7,245	$6.18	3	$206
Millet	4,333	1300	lb/acre	3	1	–	2,816	$0.09	3	$174
Potatoes	4,184	270	cwt/acre	2	100	–	56,487	$6.90	7	$138
Sugarbeets	4,097	25.5	tons/acre	2	2000	–	104,484	$46.00	8	$46
CRP	469,574	1.6	tons/acre[b]	4	2000	–	742,679	$60.00	4	$60
Grass	301,281	2.4	tons/acre	4	2000	–	724,163	$60.00	4	$60
Mixed Forage	121,133	2.4	tons/acre	4	2000	–	291,157	$60.00	4	$60
Fallow	111,242						–			
Total	*4,181,578*						**5,917,772**			

[a] References:

1. 2008 U.S. Department of Agriculture Farm Service Agency Acreage Report.
2. www.usda.gov/nass/PUBS/TODAYRPT/crop1108.pdf (accessed Dec 2008).
3. www.ag.ndsu.edu/pubs/agecon/ecguides/NorthCent_08Bud.xls (accessed Dec2008).
4. See “Hay” calculations in Table A-5.
5. http://chestofbooks.com/gardening-horticulture/farming/Farm-And-Garden-Rule-Book/Legal-Weights-of-the-Bushel.html (accessed March 2009).
6. www.bioeconomyconference.org/08%20Presentations%20approved/Breakouts/Economics%20and%20Policy/Leistritz,%20Larry.pdf (accessed Dec 2008).
7. www.farmandranchguide.com/articles/2008/10/10/ag_news/production_news/prods13.txt (accessed Dec 2008).
8. Average in Mayville, North Dakota, 2008.

[b] Corn grain only; sunflower seeds without hulls.

[c] U.S. Department of Agriculture Conservation Reserve Program.

[d] Assumes 3-yr management plan and access to lands expiring within 5 years.

Table B-2. Biomass Waste Resource Assessment Within GRE Study Region*

Source	Type	Tons/yr	*Market Price/ Delivery Cost* Per Ton	Ref.
	Crop Residuals	*2,998,167*	*$67*	
	Hay Harvested	546,642	$60	
Regional Farmers	Wheat Straw	686,451	$80	1
	Corn Stover	1,212,953	$69	1
	Sugar Beet Foliage	104,484	$69	1
	Processing Waste	*375,284*	*$50*	
Agricultural Processing Facilities	Corncobs	404,318	$50	2
	Sunflower Hulls	8,829	$20	
	Sugar Beet Pulp	5,457	$101	
Gavilon Grain Elevator	*Waste Grain*	*40*	*$5*	
Municipality	*Wood Waste*	*14,460*	*$63*	
Marion	(expanded to 100-mi radius)	60	$8	
Jud		40	$11	
Oakes		90	$16	
Ellendale		110	$16	
Jamestown		160	$5	
Fargo		10,000	$62	
Bismarck		4,000	$70	
	Potato Waste	*43,575*	*$12*	
Cavendish Farms	Frozen	6120		
	Fresh	22,707		
	Cake	14,748		
	Barley Waste	*54,000*	*$108*	
Cargill	Pellets	50,000	$114	
	Wet stream	4,000	$35	
Landfill	*MSW*	*330,761*	*$132*	
Fargo Landfill	(expanded to 100-mi radius)	190,380	$140	
Dakota Landfill - Big Dipper Enterprises, Inc.		115,136	$140	
Jamestown Landfill		12,964	$23	
Jahner Sanitation, Inc.		12,281	$36	
	Total	**3,859,567**		

* Values derived from company/facility contact December 2008 or estimated transportation costs (based on $4/gal diesel, 50 mi), unless otherwise noted.

** References:

1. www.greencarcongress.com/2008/07/purdue-study-co.html (accessed January 2009); ww.ontariocorn.org/

magazine/Issues/pre%20Nov%202005/ocpmag/magh801pg6.htm (accessed Jan 2009).

2. www.farmandranchguide.com/articles/2007/11/08/ag_news/production_news/prod15.txt (accessed Jan 2009).

Table B-3. Estimation of Hay Availability in GRE Study Region and Average Yield

Counties in Study Region			Area Within 50-mile Study Radius:			
County	tons*	acres	Factor	tons	acres	tons/acre
Barnes	54,000	21,500	1.00	54,000	21,500	2.5
Cass	43,000	3,500	0.22	9,406	16,000	2.7
Dickey	89,000	7,125	0.19	16,688	38,000	2.3
Eddy	63,000	3,281	0.09	5,906	35,000	1.8
Foster	32,500	12,250	0.88	28,438	14,000	2.3
Griggs	46,000	20,700	0.90	41,400	23,000	2.0
Kidder	324,000	18,500	0.13	40,500	148,000	2.2
LaMoure	97,000	35,000	1.00	97,000	35,000	2.8
Logan	151,000	18,500	0.25	37,750	74,000	2.0
Ransom	96,000	13,563	0.44	42,000	31,000	3.1
Steele	15,000	1,625	0.41	6,094	4,000	3.8
Stutsman	167,000	72,430	0.99	165,695	73,000	2.3
Wells	56,500	1,219	0.03	1,766	39,000	1.4
		Total Harvested		546,642	229,192	2.4

* www.nass.usda.gov/Statistics_by_State/North_Dakota/Publications/County_Estimates/2007/ cehay07.pdf (accessed Dec 2008).

Table B-4. Estimation of Crop Residuals and Agricultural Processing Waste Availability in GRE Study Region

Type	Grain 2008 Yield (tons)	Conversion Factors*	Ref.	Tons/yr
Wheat Straw	686,451	1:1 Grain-Straw	1	686,451
Corncobs	1,617,271	4:1 Grain-Cobs	2	404,318
Corn Stover		1:1 Grain-Stover/Cobs	3	1,212,953
Sugar Beet Foliage	104,484	1:1 Beets-Foliage		104,484
Sugar Beet Pulp		5% Beets		5,457
Sunflower Hulls	50,451	15-20% Seeds		8,829

* Values derived from company/facility contact December 2008, unless otherwise noted.

** References:

1. www.cropsci.uiuc.edu/research/rdc/dekalb/publications/2007/

PredictingWheatStrawYieldsFinalReportToExtensionMay2007.pdf (accessed Jan 2009).

2. www.unc.edu/~rowlett/units/scales/bushels.html (accessed Dec 2008).
3. http://renewables.morris.umn.edu/biomass/documents/Zych-ViabilityOfCornCobsAsABioenergyFeedstock.pdf (accessed Jan 2009).

APPENDIX C

CALCULATIONS FOR BIOMASS YIELD HISTORY AND SENSITIVITY

Table C-1. Crop Acreage 5-year History

	acres*					
Crop	2004	2005	2006	2007	2008	Average
Corn	432,793	323,737	413,545	679,900	721,996	514,394
CRP**	559,874	562,403	560,201	561,706	469,574	542,752
Wheat	717,528	820,389	637,935	618,986	641,543	687,276
Sugar Beets	5,187	5,268	5,677	5,424	4,097	5,131

* FSA acreage reports.

** U.S. Department of Agriculture Conservation Reserve Program (CRP).

Table C-2. Yield Estimation over 5-year History

	tons					
Crop	2004	2005	2006	2007	2008	Average
Corn	969,456	725,171	926,340	1,522,975	1,617,271	1,152,243
CRP	885,498	889,497	886,014	888,395	742,679	858,417
Wheat	767,755	877,817	682,590	662,315	686,451	735,386
Sugar Beets	132,257	134,337	144,769	138,301	104,484	130,829

Table C-3. Biomass Yield Estimation over 5-year History

	tons					
Biomass	2004	2005	2006	2007	2008	Average
Corn Stover	727,092	543,878	694,755	1,142,232	1,212,953	864,182
Grasses*	885,498	889,497	886,014	888,395	742,679	858,417
Wheat Straw	767,755	877,817	682,590	662,315	686,451	735,386
Sugar Beet Foliage	132,257	134,337	144,769	138,301	104,484	130,829
Corncobs	242,364	181,293	231,585	380,744	404,318	288,061

* CRP grasses, switchgrass.

Table C-4. Estimated Biomass Yield Sensitivity

		Worst Case	
Biomass	Variance	Min. tons	Max. Use
Corn Stover	34%	543,878	12%
Grasses*	8%	742,679	8%
Wheat Straw	12%	662,315	9%
Sugar Beet Foliage	12%	104,484	57%
Corncobs	34%	181,293	34%

* CRP grasses, switchgrass.

Appendix B

Factors Affecting Agricultural Biomass Supply

F. Larry Leistritz, Dean A. Bangsund, Nancy M. Hodur, and Donald M. Senechal[1]

Great River Energy (GRE) is a Minnesota-based generation and transmission cooperative that supplies electricity to a number of rural electric cooperatives in Minnesota. GRE is constructing a 99 megawatt Combined Heat and Power Plant near Spiritwood, ND. GRE is exploring co-firing with biomass up to 110 mmBTU/hour (7 to 10 tons/hour of biomass depending on energy content). Construction on the power plant is expected to be completed in 2010. It is expected that co-firing biomass would begin after the plant is up and running and additional permitting completed, likely sometime in 2012.

In 2008, GRE received a grant from the ND Industrial Commission to determine whether perennial grasses and other sources of biomass can be feasibly and economically delivered to the Spiritwood site. GRE has subsequently subcontracted with a research group in the Department of Agribusiness and Applied Economics at North Dakota State University (NDSU) to explore the process by which biomass might be supplied to the plant. In particular, the NDSU team was asked to develop a process schematic for each type of biomass, showing where each value added step is performed and to evaluate the prospects for converting existing cropland to perennial energy crops.

Methods

The analysis reported here builds from previous research. Bangsund et al. (2008) estimated production costs for switchgrass in south central North Dakota and calculated prices that would provide returns competitive with the current crop mix. Leistritz et al. (2006) estimated costs for harvesting and transporting wheat straw to a biorefinery. To address issues and alternatives for biomass supply, the study team conducted three focus group meetings with agricultural producers in the Spiritwood area. These meetings were held in March, 2009 and involved 21 producers.

Findings

Process Schematic for Biomass Supply

The essential processes for harvesting and delivering biomass are illustrated in Figure 1. Since the predominate land use in the Spiritwood study area is agriculture, the leading biomass sources are agricultural – either agricultural residues or a

[1]Leistritz is professor and Bangsund and Hodur are research scientists in the Department of Agribusiness and Applied Economics, North Dakota State University, Fargo. Senechal is Founding Principal and Chair of The Windmill Group, LLC, Bismarck.

dedicated energy crop. For agricultural residues, biomass harvest should occur as soon as possible after the grain harvest (typically August for wheat and October for corn). For dedicated energy crops, it may be desirable to delay harvest until after a killing frost, as this would allow nutrients to return to the roots, lessening the need for periodic fertilization. A delayed harvest would also likely lead to a reduced moisture content, aiding in transportation and storage.

Harvest would typically consist of baling. Balers forming large round bales are the predominate forage harvest equipment in the region. Equipment is widely available, and the processes used to collect and transport round bales are well tested and technically feasible for large-scale biomass collection. After baling, the bales would be stacked at the field side and then transported either to the Spiritwood plant or to an intermediate storage site. Producers felt it would be important to remove the bales from the field within 30 days. At either the Spiritwood plant or an intermediate site the biomass will require additional processing, grinding or pelleting, prior to being fired. A pelleted product would be more convenient to handle and store, but pelleting will add cost to the biomass, which will need to be taken into account.

If a dedicated energy crop were chosen as the feedstock supply, agricultural producers would need to select a grass species or mix of grass species and establish the stand. Given the climate of the study area, it is assumed that the crop will be a perennial grass. Harvest could begin in the second year. After cutting the grass with a mower or swather, the subsequent steps would be the same as for residues (Figure 1).

Whether the feedstock comes from energy crops or agricultural residues, provisions to store substantial amounts of feedstock must be made. The GRE plant needs a steady supply of biomass throughout the year. However, feedstock harvest is limited to a relatively narrow time window (at most August - October). Biomass storage will be a key consideration considering the relatively short harvest window and the bulk density of biomass. Storage at field sites will not likely be acceptable to all producers.

Another consideration in organizing the biomass supply chain is how to manage variability of biomass production. Yields of grasses can vary considerably from year to year, based on local growing conditions. Table 1 shows yields of a generally analogous crop ‘other hay’ in Stutsman County from 1997 to 2006 (‘other hay’ is comprised mostly of grasses). The hay yield in the worst year (2003) was only 68 percent of that in the best year (2000). Provisions must be made to address potentially wide annual fluctuations in biomass production. Many questions remain on how a biomass supply chain will operate, and how annual fluctuations in grass yields might affect supply structure is difficult to predict at this time.

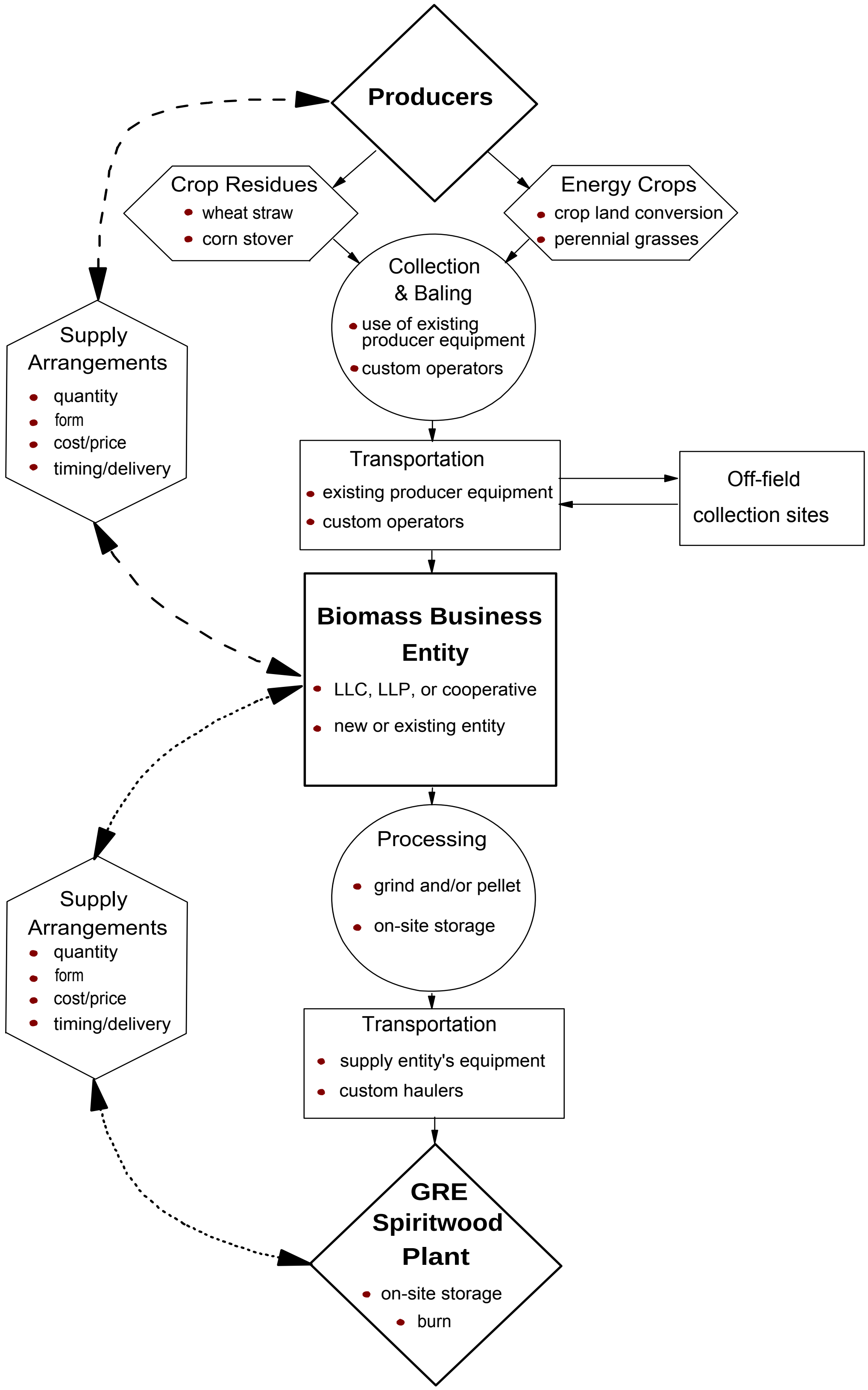

Figure 1.

Biomass Logistics and Potential Business Model Schematic

Table 1. Yields of 'Other Hay' in Stutsman County, ND, 1997 - 2006

Year	Yield (tons/acre)
2006	1.29
2005	1.44
2004	1.50
2003	1.21
2002	1.27
2001	1.51
2000	1.79
1999	1.44
1998	1.59
1997	1.32

Source: *North Dakota Agricultural Statistics*, various issues.

Prospects for Land Conversion/Estimated Supply Price for Energy Crops

Bangsund et al. (2008) evaluated supply prices for switchgrass (or a similar energy crop) in south central North Dakota. Their central premise was that for producers to consider converting land to an energy crop, they would need to receive a return equivalent to what they could expect to receive from competing crops. The breakeven prices across three soil class groups ranged from $47 per ton on soils marginal for crop production to $76 per ton for the best soils. These are prices for bales in the field. To estimate a delivered price one would need to add $5/ton for gathering at field side and loading and $10/ton for transportation to the plant (assuming a 25-ton load and 50 mile one-way haul distance). Thus, the estimated delivered cost would range from $62 per ton for grasses on marginal soils to $81 per ton on highly productive land.

Agricultural residues are the major alternative to an energy crop. Wheat and other small grain straw would be the lowest cost residue that is available in sufficient quantities. What level of incentive payment producers would expect for straw or stover is unknown at this time. Many previous studies have assumed an incentive of $10/ton or less. Some studies have also assumed that growers would be compensated for the nutrient value of the removed residues, but these assumptions have not been subject to a market test. Recently, a Nebraska group has reportedly been offering $15/ton for corn stover (Kenney 2009). This payment is apparently intended to compensate for lost nutrient value plus providing the producer an incentive.

If we assume that $15/ton would be will be seen as an adequate payment for wheat and small grain residues, harvest and transportation costs must be added to estimate total cost. Typically baling and transportation costs are $14/ton for baling straw, $5/ton to gather and load, and $10/ton for transportation (maximum delivery distance of 50 miles), for a delivered cost of $44/ton. Harvesting corn stover requires an extra step of shredding the stover with a flail chopper. This extra process step would add $10/ton to the cost of delivered biomass. Thus, an estimated delivered price for corn stover would be $54/ton. Since payment for agricultural residue and its handling will be made in a short period (about two months) while revenues from its combustion will be spread over a year, significant interest charges will be incurred. It is estimated that these charges will add 5% to 10% to total cost,

Further, since the procurement entity will likely be a for-profit business, it can be anticipated that an additional 10% to 18% can additionally be expected to be added to the initially delivered price.

While marginal crop lands clearly have an advantage over productive crop lands for acquisition costs for perennial grasses, the current prospects for wide-spread land conversion in the region appear limited. In focus group interviews, producers expressed the most interest in land conversion with respect to saline/alkaline soils. However, they were quick to point out that very few fields are comprised entirely of those soils, and that those 'trouble' spots would not justify converting entire fields to grass. Further, at this point, agricultural residues are likely to be available in sufficient quantities at prices lower than what perennial grasses might cost. These factors suggest that widespread land conversion to dedicated energy crops given current project parameters does not appear likely.

Incentive Programs

Federal and state incentive programs may affect the costs of supplying biomass. The 2008 Farm Bill includes two programs that provide incentives that may have potential to supply resources to producers to create a biomass supply. The Biomass Crop Assistance Program (BCAP) is a new program that directs USDA to establish project areas in which potential biomass producers and a biorefinery or other facility agree to produce and use biomass for conversion to advanced biofuels or bioenergy. The program would pay eligible producers up to 75 percent of the costs of establishing an energy crop, plus annual payments to help compensate for lost opportunity costs until the crop is established. The program will also provide cost-share payments for collection, harvesting, storage, and transportation costs up to $45 per ton. The program is funded with uncapped mandatory funding of approximately $70 million over five years. However, the USDA rule making process is still ongoing, and no payments are expected to be made until 2010.

Preliminary information from the USDA (USDA-FSA 2009), however, indicates that residues from crops that are eligible to receive payments under Title I of the 2008 Farm Bill are not eligible for BCAP payments. Thus, the BCAP program has the potential to substantially affect the economics of biomass supply. Returning to the example of an energy crop from low productivity farmland, the estimated supply price is $62/ton, but if eligible for cost share payments on a dollar for dollar matching basis, the delivered cost could drop to $31/ton – less than the delivered cost of crop residues. The BCAP payments to offset establishment costs could cut the supply price still further.

In order to qualify for BCAP payments, a project area application must be submitted and approved by USDA (USDA-FSA 2009). The application must include a description of the eligible land and eligible crops and a letter of commitment from a biomass conversion facility. Project area selection criteria appear likely to include the amount and types of crops produced and the importance of BCAP payments to insure an adequate supply, the local economic impact of the project, the opportunity for local investors to participate in ownership, opportunity for participation by beginning or socially disadvantaged farmers, and environmental impacts of the proposal. If the project area application were approved, producers would be required to enter into individual contracts. These contracts would be for a five year term for annual and perennial crops.

The Conservation Stewardship Program (CSP) is a voluntary conservation program that encourages producers to address resource concerns comprehensively by undertaking additional conservation activities and improving, maintaining, and managing existing conservation activities. CSP received mandatory funding over the next decade which combined with existing funding carried over from the 2002 Farm Bill should make 13 million acres eligible for enrollment nationally on an annual basis. The USDA is conducting a rule making process with the proposed rule expected to be issued in June of 2009.

Producer Issues/Focus Group Findings

Several factors may influence producers' willingness to supply biomass. Livestock producers and producers in areas with sandy soils had minimal interest in supplying biomass. The general feeling was that little unused biomass is available. Livestock producers indicated they use nearly all available forage for livestock production. Even small grain straw, in some cases, is baled and mixed with higher grade forage. They were also concerned that additional demand for biomass may act to increase forage prices. In the focus groups, producers with predominately sandy soils appeared to place a greater value on retaining agricultural residues on their fields than what would be gained from supplying biomass. Producers with more productive soils, however, appeared more willing to harvest residues and indicated they thought ample biomass was available. In particular, areas with high corn yields already require removing stover to manage seed bed preparation. Those areas were deemed to be a strong match for supplying biomass and providing for residue management. In general, the higher the production potential of crop land and the more crop enterprises predominate on existing farms, the more receptive producers were to the concept of supplying biomass.

Producers also expressed concern about contracts. Some producers cited problems with supply contracts. They specifically cited contracts that were not honored by a local ethanol plant and a malting plant. In general, there appeared to be some skepticism regarding contracts. Several producers mentioned the need for an ‘act of god’ clause in contracts. Also, because of the great variability in yields from year to year, producers seemed to favor contract terms based on acreage rather than tonnage.

Producers in all focus groups commented on the lack of labor. Current operations strain available labor supply (generally themselves and other family members) and indicated their ability to supply biomass would be limited by labor. Many producers were unwilling or lacked the appropriate equipment to bale biomass, while others indicated that they suspected custom operators would be more than willing to fill the void. Even though some producers indicated they might be able to bale biomass, they indicated that field removal and transportation would have to be provided by the supply entity.

Producers viewed converting marginal land to a dedicated energy crop somewhat favorably, provided the economics and contract terms were acceptable. While what would constitute favorable terms was not clear, biomass production would definitely need to be competitive with current crop production. Producers expressed the most interest in a dedicated energy crop that would grow on alkaline soils.

In general, producers did not quickly recognize the collection and sale of biomass as a business opportunity. Rather their first reaction was to hypothesize how it might affect their farming operation. Once the concept was presented or understood as an opportunity to sell an additional product from their existing enterprise(s), producers were more open to the concept.

Producers also seemed leery of investing in a new cooperative organization. This may be due to recent losses from failed ventures in the region. Producers did not seem eager to provide investment capital to create a new producer owned entity.

Perhaps the most striking finding from the focus group meetings was that producers had little to no prior knowledge of either the power plant or that the plant intended to burn biomass. Considering producers’ lack of awareness of the Spiritwood project and the lack of available detail on contract terms, pricing, logistics and other aspects of the business arrangement, producers did a good job of articulating their concerns and viewpoints. They were able to provide valuable insight into potential issues related to biomass supply and production for the Spiritwood project.

Entity to Coordinate Biomass Supply

One of the findings of this study is that there is a need for an entity to coordinate the logistics of biomass supply. With the plant potentially requiring biomass from

30,000 acres, a substantial number of producers would need to be involved. Further, the focus group participants strongly indicated that many producers would only be interested in supplying biomass if the harvest and particularly transportation could be handled by custom operators. A supply entity could contract with GRE to supply specified amounts of biomass on a mutually agreeable schedule. It could then contract with growers for specified amounts of either agricultural residues or energy crops. Once agreements were in place, the entity could coordinate with custom balers and truckers to schedule harvest and delivery.

There are several possible business models for the supply entity. Given North Dakota's history of cooperatives and other producer owned ventures, two that invite special consideration are the new generation cooperative (NGC) and the limited liability company (LLC). New generation cooperatives have often been formed by groups involved in agricultural processing. Producers are invited to buy shares, and the shares carry with them a delivery requirement which guarantees the plant will have adequate product to process. Membership is limited to active farmers. Some NGCs enjoyed substantial success, but over time some concerns emerged. The requirement that members be farmers restricted the number of potential investors. Also if the NGC did business with nonmembers, the proceeds were taxable (income from business with members is passed through and taxed only at the level of the individual member).

Because of perceived limitations of the NGC model, many of these organizations have been converted to limited liability companies (LLCs) (Senechal et al. 2007). LLCs do not have delivery requirements and membership is not limited to farmers. Further most value-added producer owned entities started since the mid-1990s have organized as LLCs. If a new producer owned entity were to be created, it would likely be organized as a LLC. These entities do not have delivery requirements and membership is not limited to farmers.

As previously discussed, few focus group participants expressed interest in making a major investment. Some, however, could see an opportunity based on (1) a virtually guaranteed market based on mandates and (2) absence of established competitors. More work is clearly needed to inform producers of the potential opportunity to supply feedstock to the Spiritwood plant. This could be a unique opportunity to create a supply entity, which would then be well positioned to supply biomass to other users (e.g., cellulosic ethanol producers). However, in view of the apparent reluctance of producers to make substantial investments or assume significant risk, GRE assistance in financing the supply entity would be desirable, and perhaps necessary to induce producer investment.

Another potential option does not assume the creation of a new entity. An alternate model would be that of an existing entity that would expand operations and assume the role of intermediary between producers and GRE. Custom balers and haulers or an existing supply coop may be examples of existing businesses that could take on the role of the supply entity. Customer balers and haulers would seem to be well positioned as they are currently baling and transporting biomass albeit for a different application than discussed here.

The cost structure for biomass presented earlier assumed thay Great River Energy will own and operate the processing, (e.g., pelleting) facility. Further, it has been assumed that traditional bale coverings will be sufficient to maintain quality. Thus, no cost provision has been made for construction of bale storage structures and their operation.

Contracting Considerations

Contracting would likely occur at two levels. GRE would contract with the supply entity to supply biomass. Pricing would likely be based on BTU content. Preference for a particular form of biomass (e.g., energy crop), would be reflected in pricing.

The supply entity then would contract with individual farmers to supply biomass. Initially the source of biomass will likely be agricultural residues. Because of the time it takes to establish a dedicated energy crop and the fact there is no established market for dedicated energy crop it seems likely that at least initially biomass supply would come from agricultural residues. Naturally federal and state incentive programs could affect this assumption dramatically. As time goes on the supply will likely be a combination of residues and energy crops. The annual variability of energy crop yields alone suggests that is may be difficult to meet supply requirements from energy crops alone. Even if dedicated energy crops become the predominate supply of biomass, agriculture residues may be necessary to make up for yield shortfalls.

Contracts for agricultural residues would likely need to be negotiated annually so that the quantities could be adjusted based on annual variations in yields (particularly if energy crops were part of the supply). Focus group members felt that producers would accept annual contracts to supply residues and would be comfortable contracting to supply a given quantity of biomass. The timing of the contracts would have to be such that producers would have a reasonable estimate of their biomass yield. That is the contracts would need to be entered into around the time of biomass harvest, not prior to the beginning of the growing season.

Alternately contracts for dedicated energy crops would likely be multi-year contracts as producers would need an assured market for the crop. As previously stated, currently there is no established market for dedicated energy crops. Dedicated energy crop producers would likely prefer to supply the biomass from a given acreage (rather than a given quantity of biomass) because of year-to-year variability of yields.

Contracts will likely need to incorporate a mechanism for adjusting contract prices over time to reflect changes in returns from crop production. Recent experience with Conservation Reserve Program (CRP) contracts helps explain this concern as CRP rental rates became uncompetitive with crop returns when commodity prices escalated in 2007 and 2008. Prices for either residues or energy crops should be based on BTU content and should specify producer requirements for baling, handling and transportation.

Discussion and Recommendations

The most salient finding of this study is that area agricultural producers have a very limited awareness of the Spiritwood project and the potential opportunity it represents. Additional meetings with area producers should be a high priority beginning soon after the harvest season. These meetings should be coordinated with NDSU Extension as that organization has long established and continuing ties to area producers. There also seems to be quite a bit of variability in producer willingness to supply biomass within the 50 mile radius. Livestock producers were particularly concerned with the potential impact on the forage market, while those with less reliance on livestock and/or with more productive crop land appeared more willing to participate in supplying biomass.

Given the agricultural nature of the study area, agricultural residues and energy crops will be the most abundant potential feedstocks. Wheat and small grain straw will be the lowest cost feedstock, followed by corn stover. Once the rules of federal and state biomass incentive programs are known, the relative costs of alternative feedstocks should be re-examined in light of these programs.

Labor issues may also be a key consideration for any supply entity. It does not seem likely that all producers will be either willing or able to bale and transport feedstock. Accordingly, an important component of either a new supply entity or expansion of an existing entity would be its ability to not only negotiate and coordinate supply contracts with both GRE and producers, but also the ability to either perform or contract for services for baling and transportation of biomass.

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Appendix C

Producer Economic Model

A Final Report to:

Great Plains Institute

From:

Dr. Cole Gustafson
Mr. Ronald Haugen
Mr. Doug Tiffany

May 29, 2009

Biomass Producer Economic Model

Abstract

The goal of this project was to develop a Producer Economic Model (PEM) that will assist prospective biomass suppliers (farmers) with their decision to produce, price, densify, and deliver quality feedstock to a combined heat and power (CHP) delivery site near Jamestown, ND. Essentially the PEM is an Excel spreadsheet that compares total net economic returns from a biomass enterprise with both current (e.g. present year) income and expenses from an existing crop, and future returns from establishing a new biomass production enterprise. The latter is more complicated because rotational decisions involved with production of a new biomass crop impact disease cycles, nutrient availability, environmental amenities, and risk bearing capacity of the firm. Moreover, many producers are unfamiliar with valuing economic benefits generated from soil tilth, increased fertility, reduced erosion, and carbon sequestration.

Prior to the study, it is unknown how competitive a new biomass enterprise would be because each farm situation and location is unique. Therefore, the PEM decision aide is expected to be a valuable tool for each individual producer. For those producers who are unwilling to invest their time to calibrate the PEM to their own farm situation or lack sufficient data and/or knowledge, generalized input data was created to assist them with a general overview of the investment opportunity and conclusions. They are then directed to local resource people who can assist them in compiling more accurate data.

The model was tested in a focus group of farmers who were located within the supply range of the CHP site. The half-day focus group session introduced farmers to the opportunity, engaged them with Steve Flick who is an existing biomass purchaser for Show Me Energy Cooperative, and then presented them with an overview of PEM. When polled anonymously with an audience response system (ARS), the majority of participants felt the PEM would be a very useful decision tool.

The model and results of the project have been actively disseminated to producer groups, farm organizations, lenders, crop insurance agents, and academics across the region.

Biomass Producer Economic Model

The goal of this project was to develop a Producer Economic Model (PEM) that will assist prospective biomass suppliers (farmers) with their decision to produce, price, densify, and deliver quality feedstock to a combined heat and power (CHP) delivery site near Jamestown, ND. To insure supply reliability in the long run, economic returns realized from biomass production must be competitve with other market alternatives. Essentially the PEM is an Excel spreadsheet that enables comparison of these total net economic returns. Determination of comparative total net economic returns from a new biomass enterprise is complicated because they consist not only of current (e.g. present year) income and expenses, but future returns because rotational decisions impact disease cycles, nutrient availability, environmental amenities, and risk bearing capacity of the firm. Many producers are unfamiliar with valuing economic benefits generated from soil tilth, increased fertility, reduced erosion, and carbon sequestration.

Creation of a PEM is one aspect in formation of a biomass supply chain for a local CHP. Various supply chain mechanisms have been utilized in the agricultural sector to source delivered product from farmers including fixed- and variable-price production contracts, cooperative supply agreements, and open market purchases. Producer incentives to fulfill their obligation and ensuing supply risks to the purchasing firm vary under each arrangement, especially in an era of volatile commodity prices that may discourage farmers from honoring their commitments. Alternatively, the purchasing firm may find itself overpaying for its feedstock supply. Embedded in each arrangement are market premiums and discounts reflective of the quality that differing feedstocks possess.

Prior to the study, it is unknown how competitive a new biomass enterprise would be with existing agricultural commodities because each farm situation and location is unique. Therefore, the PEM decision aide was expected to be a valuable tool for each individual producer. For those producers who are unwilling to invest their time to calibrate the PEM to their own farm situation or lack sufficient data and/or knowledge, generalized input data was created to assist them with a general overview of the investment opportunity and conclusions. They are then directed to local resource people who can assist them in compiling more accurate data.

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In addition to farmers benefiting, another expected outcome of the project was that the biomass plant is now more informed of farmer's willingness to supply biomass feedstock at varying offering prices. Incorporation of an audience response system (TurningPoint, 2008) conveyed producer interest real time. When TurningPoint results are aggregated over producers in a given region, the CHP plant has, in essence, a supply schedule of available biomass. As rural communities are indirectly affected by the economic growth of biomass CHP plant activities, they will be highly interested in results of this study. Finally model results will guide policymakers as they refine incentives and regulations impacting growth of the biomass production industry.

Background

The opportunity to use agricultural crops for energy production is a recent phenomenon. Originally, agricultural crops, especially corn, were targeted and directly converted to liquid biofuels. More recently, growth of gasification, co-firing, and cellulosic conversion has heightened interest in other agricultural crops and energy conversion processes.

Corn for Liquid Biofuel

Corn grain is the currently the preferred feedstock for ethanol production in most areas of the country. In a recent policy analysis evaluating the impact of alternative renewable energy mandates in the U.S., FAPRI forecasts that upwards of 5.05 billion bushels of corn will be utilized annually for ethanol production from 2011-2017 under their baseline scenario, over one-third of the U.S corn crop (Thompson, 2008).

North Dakota ranks 12th in national ethanol production (Renewable Fuel Association, 2008). The state is also among the most northern regions of ethanol production with 5 existing plants, although one plant is being restructured under bankruptcy.

However, corn production in North Dakota is risky given a short growing season and field conditions that are often adverse due wet planting and harvest conditions. In the past 4 years, at least one year (2004) had a crop insurance loss ratio of 2.00 which is nearly twice the national goal of 1.07 (USDA Risk Management Agency). Thus, North Dakota will be an important national supplier of ethanol with corn grain being the preferred feedstock, although production of corn grain for ethanol feedstock entails variability and high risk.

Demand Growth for Biomass

While corn grain may have been the preferred feedstock for ethanol production in the past, increasing emphasis is now being placed on development of biomass-to-ethanol production. The Energy Indepenence and Security Act of 2007 defines two new classes of biofuels – Advanced Biofuels and Cellulosic Biofuels. Each is differentiated from conventional corn starch based ethanol on the basis of potential greenhouse gas (GHG) reduction. Advanced biofuels must reduce GHG by at lease 50 percent whereas cellulosic biofuels must reduce GHG by 60 percent. In addition, the energy balance of both advanced and cellulosic biofuels (hereafter both are generally referred to as biomass) is superior to existing gasoline, diesel and ethanol from corn grain (Wang, 2005). Thus, consumers who are concerned with either climate change or the U.S.'s reliance on foreign energy supplies favor growth of these new biofuels.

At present, scientists are evaluating the biomass feedstock potential of a wide array of plant materials and crop residues. These include most existing agricultural crops, grasses, trees, specialty fruit and vegetable crops and even new crops that have previously not been raised commercially such as miscanthus and jatropha. Collection of corn stovers, especially corn cobs, appears to be one of the most viable opportunities for biomass-to-ethanol production, whether as an advanced or cellulosic biofuel. Stowers (2008) notes that corn cobs are twice as dense as other competing sources of cellulose (e.g. grass, crop stovers) and collection is complimentary with existing corn (grain) harvest processes. Corn cob harvest technology was pilot tested by Poet in 2008 with several alternative cob collection systems under study. Brechbill, et al. (2008) finds that corn is a lower cost source of cellulose relative to switchgrass and also provides greater carbon reduction. Lee (2008) has stated Chippewa Valley ethanol plant in Benson, MN will focus on corn cobs because they produce one-third less ash compared with other biomass sources. He also states they are the least useful part of the plant for soil replenishment.

Nevertheless, additional field time is required to collect corn cobs or biomass from a competing crop for biomass-to-ethanol production. If the biomass is collected jointly with the grain as a mixture and later separated at the plant, additional time is needed for more frequent unloading stops and transportation of the bulkier product because existing harvesting and farm transportation equipment is of fixed capacity. Collection of the biomass and stovers separately in the field involves another process that competes directly for scarce field time and entails greater cost due to additional field operations and transportation.

Harvest field time is extremely limited in North Dakota. The number of available fall harvest field days in North Dakota is limited by both fall rains and early frost. The exact number of available in North Dakota is unknown at present but would be invaluable to producers who are contemplating future collection of their biomass. Similar data has been complied for Iowa (Edwards and Hanna, 2008). Such data has been utilized in machinery management and investment studies to determine the economic value of a larger capacity machine which reduces harvest losses (Boehlje and Eidman, 1983). Not only are current year harvesting activities affected by these strategic machinery investment decisions, but primary field tillage must also be performed after the crop is harvested before winter in most Northern Plains states. Therefore, timeliness and yield considerations of a future crop year are also impacted by decisions made with respect to harvesting activities of a present year or current crop.

North Dakota farmers are very interested in adding additional value to their crop by collecting biomass for processing. However, they are deeply concerned about the impact additional biomass collection activity will have on their existing operation, both in the current year as well as in future years. For example, under which economic price and/or technology climates should biomass and/or stover harvesting be viewed as a priority, concurrent, or secondary enterprise activity relative to other harvest operations? An additional complication is the nutrient value of residual biomass left in a field is becoming increasingly valuable as fertilizer prices escalate. Presently, limited quantitative information exists to help producers evaluate the economic trade-offs involved as weather patterns, corn prices, nutrient values and the potential profitability of new biomass technologies are rapidly changing with the passage of time.

Finally, collection of biomass alters carbon sequestration in future years. Depending on prodution methods and carbon credit prices, the economic value of biomass varies.

Methods

The overall goal of this project was to develop a PEM of biomass harvest timeliness and apply it to selected North Dakota grain farms in the study area to assist them in delineating the economic value of developing a new biomass production enterprise.

Specific steps of this project are:

1) Convene initial panel of farmers with assistance of local country agent in region with most promising biomass inventory to a) provide overall guidance to development of the biomass feedstock supply chain including market structure, ownership alternatives, and time considerations, b) comment on plan for developing the PEM model, and c) identify key economic, environmental, and societal factors impacting longrun sustainability of the supply network. This critical step invests key farm suppliers, gives them ownership in the overall development process, and prepares them for peer-to-peer education that is so critical to final success of the project

2) Quantify available fall harvest field days in North Dakota and inventory existing farm operations which would compete with biomass collection.

3) Use results of Inventory, Densification Options, and Process Schematic (e.g. other joint contributors to project) to develop alternatives for inclusion in PEM as well as specification of premiums and discounts for economic consideration.

4) Construct a PEM to evaluate economic value of biomass collection, given changing commodity prices, weather patterns, biomass technology, nutrient and carbon credit values, environmental and soil impacts, and available field days for farms of different size, location, and production method. Rural development and societal impacts of alternative strategies were reviewed. Experts with subject matter knowledge in soils, agronomy, range management were involved, as appropriate, to ensure a strong technical foundation. Their involvement had an added benefit of investing them in the project as their views will be instrumental in shaping producer perceptions and decision-making during rollout of the CHP project.

5) Use results of Biomass Inventory to identify location of farmers to serve as a second panel reviewer of PEM. TurningPoint, an audience response system will be utilized to

immediately identify, quantify, and determine aggregate producer reaction to important program provisions of PEM as it relates to their specific farming situation.

6) Use the PEM simulation model to examine economic tradeoffs between traditional crop activities and new biomass enterprise in the region.

Prior studies have ascertained costs of collecting biomass in the northern plains. Bangsund, et.al. (2008) determined breakeven prices for switchgrass that was raised on soils of differing productivity in North Dakota. At constant yield increases, average breakeven prices for switchgrass were $75.75 per ton. Perrin, et. al. (2008) found a wide range of yields and costs across five production years and ten sites, with an overall average cost of $65.86 Mg^{-1} of biomass dry matter, and annualized yield of 5.0 Mg ha^{-1}. Prewitt, et. al. (2007) investigated the efficiency of using six alternative hay equipment methods to collect corn stovers following corn harvest in Kentucky and found that disengaging the straw chopper and spreader to produce a windrow behind the combine and then baling in a separate operation resulted in a collection efficiency of 74.1%. Prewitt, et. al was the only study which estimated costs of collecting corn stovers which appear to be the most immediate expansion opportunity for existing corn grain ethanol plants. However, that study was conducted in Kentucky on smaller scale acreage routinely found in the Northern Plains. In addition, the study assumed availability of haying equipment which again is not common on Northern Plains cash grain farms. Finally, none of the studies included timeliness considerations or the impact collection activities have on either existing and/or future farming operations.

This project began with simulation of a North Dakota grain farm to model grain and biomass harvest operations given constrained field days, uncertain weather and potential profit opportunities of each activity. The simulation model was based on an Excel spreadsheet that producers and Extension educators in the region where already familiar with – Crop Compare.

The model is flexible enough to evaluate a wide range of production systems including conventional, minimum tillage and no-till. No-till reduces the amount of fall field time required because no primary tillage must be performed before winter. However, no-till crops are slower to develop which reduces the number of available fall harvest days compared with conventional tillage. The diverse geographic regions are studied as topography and available farm equipment compliments vary which impacts timeliness considerations and the opportunity to perform additional field operations. Fewer available field days is expected to reduce the investment value of a new biomass collection, storage, and transportation enterprise. Finally, different farm sizes are considered because the scale of available machinery likely varies which again impacts the opportunity to perform needed operations in a timely manner.

Production data to calibrate the model was be obtained from the North Dakota Farm and Ranch Business Management Association (NDFRBMA). These data contain detailed financial, cost, revenue, and enterprise budget information from over 400 program participants. The sequence of machinery operations and costs thereof will be derived from this dataset. Costs of any additional or new machinery operations, such as stover collection and transport, not contained in the farm record data was estimated using MACHDATA, a machinery cost estimator (Lazarus, 2008). Nutrient value of biomass residues was gleaned from current research studies and reviewed by study collaborators. Carbon credit values were determined using Argonne National Laboratory's GREET and Liska's BESS simulation model with price date from Chicago Climate Exchange market.

Available field days were tabulated from historical North Dakota National Agricultural Statistics Service (NASS) Crop Progress and Condition weekly reports. Each report documented available field days during planting and harvesting time periods on a weekly basis. These data were the primary data supporting the Iowa study conducted by Edwards and Hanna cited above. These data were crosschecked with weather data obtained from the North Dakota Agricultural Weather Network (NDAWN). Localized historical temperature and rainfall data from the geographical areas selected were utilized to estimate soil moisture and frost density functions that constrain field operations. While the NASS data is only available statewide, the NDAWN data provided additional information that will enabled regionalization of the field day data to the specific geographic areas targeted in this study.

Environmental, fertility, and soil quality measures were adapted from Laird (2008) . NDSU campus experts assisted in localizing these relationships for the region of interest.

After the base model was developed and applied to the CHP geographic region of interest, additional situations such as differing farm sizes, ownership structures, geographic locations can be simulated to delineate the impact changing climate, commodity prices and biomass profitability have on optimal decision making. Consequently a portfolio of results will be available to producers so they can choose a strategy that aligns with their own expectations and individual situation.

Once the base model was constructed and initial results available, a second representative panel of farmers was identified to participate in the study. Their role was to review the PEM model prior to assure both accuracy and relevance. Next, they were asked to review the economic results provided. Suggestions they have for improving model performance or clarity of results were directly incorporated. Their input was used to identify the most cogent results as well as to determine the most efficient dissemination method.

Finally, model results were disseminated orally and in several written formats to inform local producers, lenders, crop insurance agents, and farm organizations of the opportunity. After results were peer reviewed to assure quality, a farmer-friendly spreadsheet decision aide (template) was developed and placed on the web so producers can select input data reflective of their own situation and evaluate the economic potential of biomass stover collection for their own situation.

Assumptions

The projects overall approach of investing key farm producers and campus colleagues in various phases of model development is assumed to provide ownership in the development of the entire supply chain. This aspect will increase the likelihood of project success and culminate in a robust decision-aide that provides a sustainable supply of biomass to the CHP plant. Moreover, invested progressive farmers and campus experts will leverage education efforts through peer-to-peer networks, which over time, have been shown to be most effective in changing farm behavior.

Feasibility of the simulation methodology is very high as the technique has been applied to similar biofuel problems that require formation of management strategies under conditions of risk. Simulation risk models have been successfully used to determine the economic value of fractionating dry beans for ethanol production (Goel, et. al, 2008). The methodology has also been utilized to assist corn ethanol plants with formation of an optimal investment strategy in fractionation equipment, given lender imposed financial constraints (e.g. sweeps) (Fewell and Gustafson, 2008).

Critical data from related studies (Biomass Inventory, Densification, Process Schematic, and Land Conversion) was added to the model over the project to sharpen its calibration.

Focus Group Meeting Summary

On March 20, 2009, a focus group with nine producers and eight members of the project was held in Jamestown, North Dakota. The purpose of the meeting was two-fold. The first goal was to present the PEM to a group of farm producers and land owners for the purpose of receiving feedback on the models relevance and accuracy. A second goal of the focus group was to begin the peer-to-peer educational program described in the previous section.

The meeting began with a presentation by Ms. Sandra Broekema which provided an overview of Great River Energy, a description of the Spiritwood project, and the critical role farm producers would play as potential feedstock suppliers. Mr. Steve Flick then acquainted the group with biomass activities at Show Me Energy including a detailed description of their financial structure and purchasing program. Importantly, the price of all biomass paid to farmers is based on three simple criteria - BTU content, moisture, and weight. Show Me Energy has developed a proprietary process to evaluate these biomass criteria real time so producers are instantly informed of value.

Evaluation of PEM

In an effort to elicit unbiased responses from producers with respect to the most important factors influencing a producer's decision to supply biomass to a site like Spiritwood, an audience response system (ARS) obtained their responses to several questions before the Producer Model was presented to them. The questions posed and responses (percent of respondents) are shown:

1) What is the most important consideration to you when considering whether or not to supply hay for biomass?

Consideration	Percent of Respondents
Profitability	80
Time Availability	10
Cost of New Equipment	10
Environmental Impact	0
Help Establish New Plant	0

Beforehand, most producers were under the impression that hay for biomass would be harvested during the same time periods that forages were normally collected, late summer and early fall. Harvesting during these timeframes usually does not conflict with other grain or livestock operations. However, Mr. Flick commented after presentation of the Producer Model that ideal biomass harvesting occurs with just one cutting in either very late fall or early spring. Available field days during these times are fewer and competition with other grain and livestock activities is higher. This is borne out in the second question which asks a similar question, but with respect to collection of corn stovers:

2) What is the most important consideration to you when considering whether or not to supply corn for biomass?

Consideration	Percent of Respondents
Profitability	64
Time Availability	27
Cost of New Equipment	9
Environmental Impact	0
Help Establish New Plant	0

The responses show that time availability is a far greater concern with supply of corn stovers due in large part to the limit time available during fall harvest. Corn harvest in Fall 2008 was extremely difficult due to wet harvest conditions. In fact many acres of corn still remained un-harvested across the state in early 2009.

To evaluate the usefulness of the Producer Economic Model after it was described to them, attendees were asked to respond to:

How Useful Will the Spreadsheet Be to Assist Your Decision to Supply Biomass?

Consideration	Percent of Respondents

Extremely Helpful	10
Helpful	80
Limited Usefulness	10
No Use Whatsoever	0

To assist with further development of the Producer Economic Model, the group was asked what additional information should be added to the model to make it more useful:

Consideration	Percent of Respondents
Use My Farm Data	40
Contain More Detail	10
Consider More Crops	10
Consider More Impacts	0
More Info on Project/Timing	40

Discussion Summary

After the formal presentations and evaluation of the PEM, a general discussion amongst all meeting participants occurred. Key points made were:

- Show Me Energy is a member cooperative and was originally capitalized at $2,500/share.
- Silica is very deterimental to all processing equipment and but Show Me Energy has developed a proprietary process to remove it.
- They leave 1/3 biomass unharvested for environmental sustainability and spot check to assure compliance. In addition, they leave 50’ buffer strips around streams and other environmentally fragil lands.
- Metal in biomass is a constant problem. One producer left a bale spear hidden in a bale which caused considerable destructive damage to their grinder.
- Two 200 hp motors drive Show Me Energy’s biomass grinders.
- Show Me Energy sell pellets at the retail level for $150/ton. Electricity produced with their product has a $0.03/kwh final cost of production.
- They prefer biomass that is as dry as possible, but consider 25% an upper limit. Producers indicated this could be a challenge, especially with respect to corn. Spoilage is not problematic. Show Me assists producers by providing pallets to store material on.
- Producers supplying large quantities of biomass have staggered delivery dates with 3 week delivery windows throughout the year
- Biomass harvesting follows sustainable practices
- Replacement price for the plant is $8 million and they process 100,000 tons/yr.
- Show Me is working to develop a fertilizer product from the ash… cost to produce is estimated to be $2/ton.

List Presentations Given

"Crop Insurance and Biofuel Update" – NDSU Barley Institute
Jan. 12 Dickinson, 15
Jan. 15 Minot, 40
"Prospects for North Dakota Agriculture in 2009" – North Dakota Farmers Union Annual Mtg.
Feb. 5, Bismarck 90
"The Future of Biofuels" National Crop Insurance Services Annual Meeting
Feb. 10, Palm Springs, CA 160
"The Future of Biofuels" International Crop Expo
Feb. 18, Grand Forks, 50
"The Promise of Biofuels" Delaware Gov. Conf.
Feb. 27, Dover 140
"Financing Cellulosic Ethanol" Precision Ag. Conf
Mar. 3, Aberdeen 200
"Financing The Biofuel Industry" Fuel the Future Workshop
Mar. 19, Morris, MN 60
"The Promise of Biofuels" ND Corn Growers Board
Apr. 2, Fargo 30
"Prospects for North Dakota Agriculture" ND Jumpstart Coalition
Apr. 15, Bismarck 80
"Prospects for Biofuel" AgCountry Hail Day
May 14, Detroit Lakes 125
"Financing Growth of Biofuel Industry" MN Ag Lenders
May 19, Moorhead 50

Leveraging Results - Grant proposal to ND Industrial Commission

To leverage results of this project and extend the educational program based development of the PEM, a $580,710 "Biomass Processing, A Mobile Demonstration and Education Program" was submitted to the ND Industrial Commission for funding consideration. Funds project obtained for this project would be utilized to develop and showcase a mobile biomass processing demonstration unit. The unit would consist of a tractor, loader, grinder, pellet machine and trailer. Demonstrations would be made at NDSU Research Extension Center field days, commodity organization annual meetings, and other events scheduled throughout the region.

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Appendix D

BEST MANAGEMENT PRACTICES
FOR
BIOMASS PRODUCTION AND HARVEST

SPIRITWOOD STATION COMBINED HEAT AND POWER FACILITY

INTRODUCTION

High commodity prices are causing landscape changes of a magnitude not seen since early settlement. North Dakota has lost 144,744 acres of native prairie from 2002-2007 and is projected to lose 1,705,179 acres (60 percent) of land enrolled in the Conservation Reserve Program (CRP) from 2007-2012. Commodity prices have recently declined which may slow grassland losses. Even so, North Dakota has lost a significant portion (~80%) of its original native prairie, making conservation of remaining prairie habitat an extremely high priority.

Spiritwood Station Project partners are working to slow or reverse the trend in grassland loss by using native grass crops for energy; essentially using energy markets to pay for good conservation practices. This document summarizes best management practices for biomass production and harvest that can be implemented in the Spiritwood Station project area to achieve conservation benefits for wildlife/natural resources; biodiversity, air quality and greenhouse gas emissions; water quantity and quality; soil health; local community economic benefits; and energy efficiency and conservation. Although the primary focus is on perennial biomass production, other biomass feedstocks, as well as conservation opportunities, are discussed.

WILDLIFE/NATURAL RESOURCES

What to Plant

Perennial, native plants will have a high potential to provide multiple resource benefits and improved net energy gain.

- Production input costs will be much lower for perennial bioenergy feedstocks versus annual crops.
- Perennial crops can provide habitat for wildlife during critical times of the year if managed with wildlife in mind.
- Little, if any, fertilizer may be required.
- Less use of pesticides should result in reduced runoff/leaching, and improved aquatic habitat.

Diverse plantings (many species) will be more sustainable, better for wildlife habitat, improve water quality, reduce runoff, and be more resistant to disease and pests than monoculture plantings.

- A diverse mix of local ecotype grasses/forbs on ecologically appropriate sites (e.g., plantings matched to ecotype region, soils, slope, rainfall) will provide the best habitat for native species and be more resistant to drought, invasive species, and other perturbations
- While pure monotypic stands of grass may be required for certain energy conversion processes (i.e., enzymatic), plantings of diverse grass and forb species are generally better from an overall wildlife production standpoint. Monoculture grasses should be interplanted with legume forbs that improve wildlife nesting and brood-rearing habitat and fix nitrogen to reduce fertilizer needs.
- A diverse planting that includes forbs will provide greater nectar sources for pollinators, including bees that are the primary pollinator of plants grown for food.
    - Research has shown that bees raised in North Dakota have better body condition than bees experiencing colony collapse.

No species of invasive grass or forbs should be allowed, either in monotypic or diverse stands, that are known to cause problems in a particular location in either adjacent cropland, CRP, or other areas planted for biomass production.

Where to Plant

Energy crops will provide the most beneficial resource values when planted on lands that have been previously disturbed, including current cropland and pasture land planted to grasses.

Converting native grasslands, wetlands, or woodlands to monoculture energy crops will result in net losses of biodiversity and must be avoided.

How to Plant (Establishment: planting methods, seeding rate and depth, time of planting)

- Information is currently available from a number of sources on establishment methodologies.

Management

<u>Harvest Characteristics</u>

The following harvest characteristics, several of which have already been shown to be of benefit to the sustainability of grassland stands, are advocated as having the most ancillary benefits to wildlife:

- <u>Stubble Height:</u> At least 12" to provide suitable nesting habitat the spring following harvest. Taller stubble provides greater nesting habitat value; however, leaving one third to one half of the area unharvested can also mitigate this issue. Taller stubble heights can improve soil moisture by catching snow and providing shading to reduce evaporative loss of rains. A minimum of 4-inch stubble height should be required to improve stand persistence.

- Frequency and Timing of Harvest: No more than every other year, between the Primary Nesting Season dates of April 1 to August 2. Benefits to harvesting native perennial feedstocks in the fall (after a killing frost), winter, or early spring include allowing the translocation of nutrients back into the roots, less moisture in the feedstock, and providing valuable nesting and brood-rearing cover for ground nesting birds and cover for other wildlife.
- Physical Characteristics of Harvest: All harvest should be conducted in blocks, avoiding strip harvest that is known to create edge that invites predation and reduces survival of ground nesting birds. Rotating harvested areas on fields (e.g., harvest a different portion of the field every year) will help maintain wildlife benefits and should improve the crop yield.

Strategy of "Harvest Reserve"

Landscape design around a selected plant location or biomass user should accommodate at a minimum an additional 20% acreage planted and dedicated to biomass grasslands. This acreage will provide a "harvest reserve" for producers to meet contract obligations in drought years but remain unharvested (and therefore wildlife habitat) in normal or wet years.

BIOMASS BMP'S GRADIENT OF BENEFITS TO WILDLIFE/NATURAL RESOURCES

BENEFICIAL
- Protect native prairie
- Retain and protect grass on expired CRP
- Plant and properly manage diverse stand of native perennial grasses and forbs
- Plant and properly manage stand of native perennial grasses and limited number of forbs
- Plant and properly manage stand of native perennial grasses

NEUTRAL
- Use wheat stubble, corn stover, and other crop residue for biomass feedstock
- Use old hay for biomass feedstock

DETRIMENTAL
- Biomass crops displace native prairie and wetlands
- Use of cattails (benefits vs detriments debatable), aquatic plants, odd areas
- Existing CRP

BIODIVERSITY

Biomass production should maintain or enhance landscape biodiversity and protect native, rare, threatened, and endangered species and habitat.

- Native prairie and wetlands, other high conservation value areas, and ecological corridors should be identified along with potential opportunities/partnerships for conservation of these natural resources.

AIR QUALITY/GREENHOUSE GAS EMISSIONS

Biomass production should maintain or improve air quality and should result in a net reduction of greenhouse gas emissions when compared to fossil fuels.

- Planting, harvesting, processing, storage and combustion.

WATER QUANTITY AND QUALITY

Biomass production should maximize water conservation, protect water resources, and maintain or improve water quality.

- Leaving a biomass buffer zone of 50 feet around all litoral and riparian bodies reduces run off and provides desirable wildlife habitat.

SOIL HEALTH

Biomass production should promote practices that improve soil health and minimize degradation of cropland. Good agricultural practices will be applied including:

- Prevention and control of soil erosion.
- Maintaining and improving soil nutrient balance, organic matter, pH, structure, and biodiversity.
- Prevention of salinization.
- No till

LOCAL COMMUNITY ECONOMIC BENEFITS

Biomass production should bolster the economic foundation and quality of life in communities where it occurs.

- Biomass production, harvesting, processing, storage and delivery offers employment and business opportunities within the local communities.

ENERGY EFFICIENCY AND CONSERVATION

Biomass production should be energy efficient and conserve natural resources at all stages of production, harvest, and processing.

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